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SCIENCE ABSTRACTS

SECTION A.—PHYSICS.

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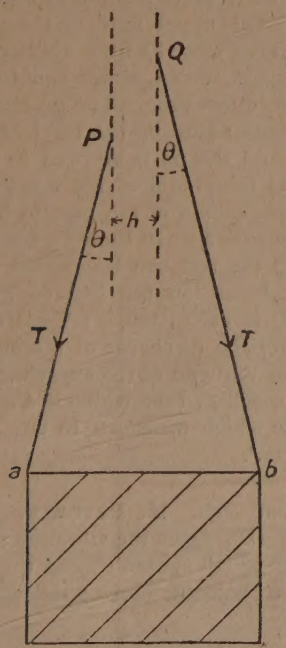
SCIENCE ABSTRACTS.

Section A.—PHYSICS.

FEBRUARY 1919.

GENERAL PHYSICS.

110. *Double Suspension Mirror.* † **L. Southerns.** (Phil. Mag. 36. pp. 477–486, Dec., 1918.)—Describes a form of double suspension mirror attachment to a balance, the mirror being suspended by two fibres as shown in the Fig., the vertical distance PQ between the points of attachment of the fibres being



assumed small compared with the length of the fibres but large compared with the horizontal distance between them. The effect of this attachment on the sensitivity of the balance is first examined, and then the sensitivity of the mirror deflection is calculated, and curves showing the results obtained experimentally are given. J. W. T. W.

111. *Isochronous Pendulum.* **H. Bock.** (Zeits. Instrumentenk. 38. pp. 157–163, Oct., 1918.)—Describes and gives the mathematical theory of a rolling pendulum with isochronous motion. For details the diagrams in the original paper should be consulted. A. W

112. *An Accurate Method of measuring the Density of Gases.* **O. Maass and J. Russell.** (Am. Chem. Soc., J. 40. pp. 1847–1852, Dec., 1918.)—For the determination of the density of gases, a known volume of the gas at known pressure and temperature is liquefied in a small bulb attached to the containing vessel; the bulb is sealed off and the liquefied gas weighed at room temperature. The error in the method used was about 1 part in 2000, but this could be reduced to less than 1 part in 10,000. The following values of density were obtained, the number in brackets being the value obtained by other investigators: acetylene, 1·1695; methyl ether, 2·1103 (2·1096); hydrogen bromide, 3·6397 (3·6438). A. F.

113. *New Method and Apparatus for measuring the Viscosity of Oils.* **G. Chéneveau.** (J. de Physique, 7. pp. 109–114, May–June, 1917.)—The method and apparatus described by the author for measuring oil viscosities is based upon the law of Poiseuille, which governs the flow of oil through a capillary tube. The apparatus consists of a small pipette, to the lower end of which a short length of capillary tube is attached by fusion, and upon the upper and lower stems of the pipette are marks representing a definite and known volume of the oil. The upper limb of the pipette is formed into a funnel above this mark, and is closed with a rubber stopper through which passes a short length of glass tubing, which can be closed as required by means of a pinch-cock and rubber tube. The pipette is filled with the oil to be tested by suction, and after adjusting the level of oil to the upper mark, the pinch-cock is opened and the oil is allowed to run out until the lower mark is reached; the exact time required for this delivery of the measured volume of oil from the lower orifice of the pipette being carefully recorded. By surrounding the pipette with a small Liebig's condenser, through which a current of water is passing, the test can be carried out at any desired temperature. The equation based on the law of Poiseuille by which the coefficient of viscosity (V) is calculated is: $V = 0{\cdot}003\ T\rho$, where T is the time required in seconds for the discharge of the oil, and ρ is the difference in pressure at the beginning and end of the experiment. The above equation only holds, however, for a capillary tube which is 4 cm. in length and 0·15 cm. in diam., and for a pipette which measures 10 cm. between the two marks and has a capacity of 10 cm.³. J. B. C. K.

114. *Vibration of Vapour Jets.* **H. Parenty.** (Comptes Rendus, 167. pp. 667–673, Nov. 4, 1918.)—Discusses the vibration forms produced by a jet of vapour having a velocity which cannot exceed the velocity of sound. The disturbances produced by a projectile moving through a medium are likewise considered. J. W. T. W.

115. *Buoyancy of Frazil Crystals in Water.* **H. T. Barnes.** (Roy. Soc. Canada, Trans. 11. pp. 61–62, June–Sept., 1917.)—By adapting Stokes' formula for the rate of fall of raindrops through air to the case of spheres of ice rising through water, the author finds that such a sphere of 0·2 mm. diam. may be expected to rise at 0·1 cm. per sec. An ice crystal of the same

volume would rise even more slowly, which accounts for the fact that the fine ice crystals found in Northern Canadian rivers show but little effect of buoyancy. J. S. Di.

116. *Elasticity of Cement.* **L. Jouane.** (Comptes Rendus, 167. pp. 591–593, Oct. 21, 1918.)—Describes experiments in which the elasticity of cement was measured by determining the amount of bending of a block under a small load gradually increased and then decreased. The absence of permanent set showed that the loads were within the elastic limit, and the modulus of elasticity was then found in this manner for several specimens, and compared with the modulus found by a vibration method. The two methods gave good agreement, about the value 1×10^6 kg./cm.^{2} for the samples tested. J. W. T. W.

117. *Compression Strength of Glass and Quartz.* **G. Berndt.** (Deut. Phys. Gesell., Verh. 19. pp. 314–327, Dec. 30, 1917. Zeits. Instrumentenk., Beib. 19 and 20. pp. 114–116, Oct. 15 ; 21 and 22. pp. 121–126, Nov. 15, and 23 and 24. pp. 134–136, Dec. 15, 1918.)—Experiments were made in the optical works of C. P. Goerz with an Amsler machine, first on cubes, up to 15 mm. side length, and then on cylinders, 5 mm. in diam. and height, placed between steel plates which were attacked by the quartz. The specimens were either all polished or only finely ground ; although the possible lesion of the surface by the grinding did not appear to make any difference in the strength, it is recommended that for all glass-testing only specimens prepared as for optical work should be used. The specimens frequently split before rupture took place with almost explosive violence. The strength decreased from 13,000 kg./cm.^{2} to 8800 kg./cm.^{2} as the cube size increased from 5 to 15 mm. in the case of mirror glass. The boro-silicate crown glass of the Sendlingen Optical Glass Works was especially tested, either most carefully cooled or rapidly cooled in air from 600° C. downward, and very badly strained therefore. The strained material gave more regular and higher strength values (18,400 kg./cm.^{2} max., 15,000 kg./cm.^{2} average), than the strainless material (16,900 kg./cm.^{2} max., 14,200 kg./cm.^{2} average), and these latter values further went down by about 7 % (to 15,000 and 12,500) when the load was not put very gradually, but in steps of 100 or 200 kg., whilst the rate of applying the load had no influence in the former case. The quartz tests, also made on 5-mm. cylinders, yielded slightly higher values when the pressure was applied parallel to the optical axis than when at right angles to the axis, the maxima in the two cases being 28,000 and 27,400, the averages 25,000 and 22,000 kg./cm.^{2}. The quartz values are higher than those previously found by A. Winkelmann and O. Schott and by Rinne, but the glass values are lower. H. B

118. *The Interferometer for the Newtonian Constant.* **C. Barus.** (Nat Acad. Sci., Proc. 4. pp. 338–342, Nov., 1918.)—The rectangular interferometer, modified by the addition of three extra pairs of mirrors, is used to measure the displacement caused in a delicate torsion balance by gravitational attraction. Data are given showing the sensitiveness and action of the instrument for the determination of the gravitation constant. In particular a method is suggested of determining this constant by taking count of the acceleration of the torsion beam ; and it is suggested that under specified conditions this could be accurately achieved, there being only three principal factors, namely, the large masses, the distance between large and small masses, and the acceleration mentioned. The present

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work is of the nature of a trial; the final work may be done elsewhere in a better situation than the one used. P. E. S.

119. *Stokes' Law for Spheres moving through Water.* **H. T. Barnes.** (Roy. Soc. Canada, Trans. 11. pp. 55–60, June–Sept., 1917.)—This paper describes experiments in which a spherical pendulum bob moving under water was received by a ballistic pendulum. The law of Stokes states that the effective inertia of a sphere moving through a fluid comes from the addition to its own mass of half the mass of the fluid that would fill the space occupied by the sphere. Spheres composed of various metals of densities ranging from 11·33 to 1·7 were oscillated in water. The results clearly indicated the general validity of the law of Stokes for the movement of such bodies in a fluid. E. H. B.

120. *Hull Form for High Speeds.* **E. Fournier.** (Comptes Rendus, 167. pp. 444–448, Sept. 23, 1918.)—The author studies the variation, with velocity V, of resistance R offered to the movement of hulls through the water, and evolves a criterion which makes possible the determination of profiles (in planes parallel to the water line) yielding minimum resistance. By the aid of a coefficient characteristic of its lateral convexity, it is possible to determine immediately the suitability of any hull for high speeds. The formulæ given are based on experiments conducted in the open with a great variety of types of vessel. Two categories of vessel must be distinguished, namely, those which maintain a horizontal position at all speeds, and those which change their plane of flotation beyond a critical speed W, for reasons and under conditions set forth in the paper. Vessels fall in the first or second category according as the coefficient ω of lateral convexity of the hull is greater or less than 0·18; where $\omega = \sqrt{(\sin I \,.\, \sin I_m)}$, I_m being the mean of the max. angles of approach I, I′ etc. of the water lines of the stem parallel to the plane of floating, among which I is that of the water line of this plane. Mathematical justification is given for the main features of design of racing boats, *i.e.* short length and flat bottom below the poop. The formulæ evolved are applied to a 35-knot torpedo-boat destroyer. In order to determine whether any form of hull is capable of assuming an inclination favourable to high speed, by submersion at the stern and corresponding rise at the stem, it is only necessary to determine whether ω is less than 0·18, with a lower limit 0·09.

R. E. N.

121. *General Expressions for the Resistance of Hulls.* **E. Fournier.** (Comptes Rendus, 167. pp. 541–545, Oct. 14, 1918.)—In an earlier communication [see preceding Abs.], the author shows that vessels suitable for high speeds are those in which the lateral convexity of their submerged surface Σ is characterised by a coefficient ω less than 0·18. The wave formed by such a vessel falls away below the stern, allowing the latter to sink and the stem to rise so as to reduce the resistance to motion. This occurs at a critical speed W. Expressions are given for the resistance R, in terms of W/V and other factors concerned, for both classes of vessels—namely, those which are and those which are not inherently suitable for high speeds. An expression is given also for the variable values of R below the speed W. Other formulæ given, which are also of general applicability within the usual limits of convexity in hulls, are expressions for the most economical speed of vessel and for the surface Σ and the volume U which it envelops. Besides the coefficient ω (characterising only the trace of the water lines of the hull), the formulæ involve

only the principal dimensions L, l, p, and the surface σ of the plane of drift. The most favourable inclination θ of the plane of flotation at speed V is given by the expression $\sin\theta = [1 - (W^2/V^2)] \sin 4^\circ 18'$. W and ω are "keys" which make possible the simple solution of resistance problems which are otherwise very complex. R. E. N.

122. *On the Equations of Motion for Matter: A Contribution to the Theory of Relativity.* **R. J. Humm.** (Ann. d. Physik, 57. 1. pp. 68–80, Sept. 25, 1918.)—In the present paper the attempt is made to give a suitable criterion for the development of the equations of motion of matter. Such a criterion has been furnished with greater or less clarity by different authors, and arises by equating to zero a special variation of the Hamiltonian invariant integral. From the equations of motion so obtained, the energy equations of Einstein are derived. Finally the idea of electromagnetic mass is introduced into the general theory of relativity. H. H. Ho.

123. *Rolling Friction.* **A. Lechner.** (Zeits. f. Instrumentenk. 38. pp. 145–150, Sept., 1918.)—There are three methods of determining the coefficient of rolling friction: (i) Coulomb's method, (ii) the inclined plane method, and (iii) the pendulum method, in which a pendulum is rigidly attached to a cylinder rolling on a plane. The author finds that the first two methods give values in good agreement, while the last gives a very much smaller value—approximately one-tenth in the case described. J. W. T. W.

124. *Rotational Oscillations of a Cylinder in an Infinite Incompressible Liquid.* **D. Coster.** (K. Akad. Amsterdam, Proc. 21. 1. and 2. pp. 193–202, 1918.)—The method here followed in the discussion of this problem is in the main that used by Verschaffelt in the analogous case of the sphere. An infinitely long cylinder executes a forced vibration rotationally about its axis. The object is to ascertain the motion established in the liquid after (theoretically) an *infinite* time (in practice, after a relatively short time) in order to compute the frictional moment of the forces exerted on the cylinder by the liquid. E. H. B.

125. *Proposed Hydraulic Experiment.* **Rayleigh.** (Phil. Mag. 36. pp. 315–316, Oct., 1918.)—In an early paper (1850) Stokes showed "that in the case of a homogeneous incompressible fluid, whenever $udx + vdy + wdz$ is an exact differential, not only are the ordinary equations of fluid motion satisfied, but the equations obtained when friction is taken into account are satisfied likewise. It is only the equations of condition which belong to the boundaries of the fluid that are violated." In order to satisfy these also, it is only necessary to suppose that every part of the solid boundaries is made to move with the velocity which the fluid in irrotational motion would there assume. There is no difficulty in the supposition itself; but the only case in which it could be readily carried into effect with tolerable completeness is for the two-dimensional motion of fluid between coaxial cylinders, themselves made to rotate in the same direction with circumferential velocities which are inversely as the radii. Experiments upon these lines, but apparently not quite satisfying the above conditions, have been made by Couette and Mallock. It would appear that, except at low velocities, the simple steady motion becomes unstable.

But the point of greatest interest is not touched in the above example. It arises when fluid passing along a uniform or contracting pipe, or channel, arrives at a place where the pipe expands. It is known

that if the expansion be sufficiently gradual, the fluid generally speaking follows the walls, or, as it is often expressed, the pipe flows *full*; and the loss of velocity accompanying the increased section is represented by an augmentation of pressure, approximately according to Bernoulli's law. On the other hand, if in order to effect the conversion of velocity into pressure more rapidly, the expansion be made too violently, the fluid refuses to follow the walls, eddies result, and mechanical energy is lost by fluid friction. According to W. Froude's generally accepted view, the explanation is to be sought in the loss of velocity near the walls in consequence of fluid friction, which is such that the fluid in question is unable to penetrate into what should be the region of higher pressure beyond.

It would be a difficult matter to satisfy the necessary conditions for the walls of an expanding channel, as the travelling bands of which the walls would be constituted should assume different velocities at different parts of their course. But, as a rough approximation, two wheels revolving in opposite directions are suggested in the hope some one will make the test.

E. H. B.

126. *Is a Moving Mass Retarded by the Reaction of its Own Radiation?* **L. Page.** (Phys. Rev. 12. pp. 371–380, Nov., 1918.)—In a recent paper [Abs. 823 (1918)], the author claims to have proved definitely the non-existence of such reaction for the Lorentz deformable electron, and, by inference, for any moving mass. In order to meet possible objections to the latter result, he treats the motion of an electrical doublet by analysis based on the same assumptions as in his previous paper, which lead to conclusions embodied in the statements that :—

(1) The problem of two charged particles with electromagnetic masses, moving under the action of each other's fields in a plane which has a drift velocity along its normal, has been treated rigorously, and no retardation found to exist as a result of the radiation emitted.

(2) Larmor's expression for the retardation due to the reaction of the radiation from the moving doublet has been shown to be a consequence of his failure to take into account the effect of damping. The assumption that damping is negligible leads to a contradiction with the electrodynamic equations. When damping is taken into consideration this inconsistency disappears and the retarding force vanishes. G. W. DE T.

127. *On Whole Numbers or Atomic Weights, and Related Questions.* **R. v. Mises.** (Phys. Zeits. 19. pp. 490–500, Nov. 15, 1918.)—The question has again come forward in modern physics as to whether the observation data for a definite group of magnitudes (*e.g.* for the atomic weights of the elements) relate to a series of integral multiples of a unit, and only diverge from these owing to experimental errors. In the case of the first 24 elements of the periodic system not less than 20 differ at the most by 0·1 from the next whole number, and it appears reasonable to assume a strong bias towards the integer hypothesis. In other cases, *e.g.* the Langevin-Weiss theory of magnetons, for whose admissibility the verdict as to the integral character of the series of numbers appears to be actually decisive [see Abs. 1586 (1912)], the need for an objective criterion occurs. Hitherto for the treatment of this problem, the sole means employed has been the Gauss theory of errors. The author demonstrates the inadequate character of this method, and develops a cyclic

theory of errors to replace the linear theory of Gauss, which admits of a more comprehensive solution being obtained. He claims to have found a definite criterion for integral character—namely, an expression which, from the observation data, gives the probability that the true values are integers. Section 1 states the problem to be solved. Section 2 derives the cyclic law of errors. Section 3 deals with measurements of precision, etc. Section 4 evolves the integer criterion. Section 5 gives applications of the theory. A short appendix deals with the calculation of the cyclic error integral. The example specially studied is that of atomic weights, and an application of the theory to modern electrical questions is promised for the near future. H. H. Ho.

128. *Atomic Structure.* **P. Debye** and **P. Scherrer.** (Phys. Zeits. 19. pp. 474–483, Nov. 1, 1918.)—Considering atoms as electrical planetary systems interconnected with one another, the authors deduce mathematical expressions relating to the distribution of electrons and atoms in crystals. X-ray crystal data are employed to verify the theory as applied to certain special cases. The paper is divided into the following sections:—(1) The question of electron-rings as "links" in crystal structure, (2) Calculation of the number of electrons connected with an atom, (3) Magnitude of the electron system of an atom.

In concluding, the authors state:—"Thus we have developed a method for determining the effective size of the planetary system of electrons in the atom. It should be observed that throughout the discussion, use has been made of 'classical' fundamental data. In the region of ordinary wave-lengths we do not know of a case which throws doubt on any of these fundamental data, and hence invalidates our conclusions. For essentially smaller wave-lengths, of course, as in the region of γ-rays, absorption observations must be considered from a new aspect. A. B. W.

129. *On Bohr's Atomic Model.* **A. Szarvassi.** (Phys. Zeits. 19. pp. 505–508, Nov. 15, 1918.)—The real essence of Bohr's atomic model is as yet unknown; *e.g.* it is inexplicable why the electron in its stable orbit should emit no radiation, or why this particular orbit should be stable, or why the transition from one stable orbit to another should be accompanied by homogeneous radiation. It is also incomprehensible why the energy-change accompanying the transition should be equal to the product of Planck's active quantum h and the frequency ν of the emitted radiation. The results, however, are established, and since no one has calculated the Rydberg constant from molecular data or obtained ν from the Balmer formula for even a single case, the author now attempts to give an explanation of Bohr's great discovery. The problem is tackled from the standpoint that it is of a purely statistical nature, and in consequence admits of the quanta theory being applied. [Errata. *Ibid.* p. 556, Dec. 15, 1918.] H. H. Ho.

130. *Photographic Tests of Einstein's Gravitation Theory.* **R. Jonckheere.** (Observatory, No. 526. pp. 215–216, May, 1918.)—The author suggests that an apparent shift in the position of a star near the sun might be caused by refraction by the solar atmosphere or by the particles giving rise to the zodiacal light, or as the result of a hypothetical ether condensation near the sun, and so make such observations valueless as criteria of Einstein's theory.

G. W. DE T.

131. *Photographic Tests of Einstein's Gravitation Theory.* **F. A. Lindemann.** (Observatory, No. 529. pp. 323–325, Aug., 1918.)—The author gives a detailed proof that sensible refraction could not arise from the first cause suggested by Jonckheere [see preceding Abs.], and points out that his argument applies *a fortiori* in the second case. The third suggestion simply amounts to attributing special properties to the ether to account for any observed abnormality in the path of a beam of light. G. W. DE T.

132. *Interfacial Tension and Complex Molecules.* **G. N. Antonoff.** (Phil. Mag. 36. pp. 377–396, Nov., 1918.)—Assuming that the molecules of liquids act as doublets the author deduces the relationship $P = k\alpha p^{1/3}$, between the molecular pressure P and the surface tension α. In this equation k is a numerical quantity, practically equal to 2 if the magnetic forces are negligible compared with those of electric origin, and p is the number of doublets or molecules in unit volume of the liquid. The phenomena of molecular attraction depend on the same forces as chemical affinity. The author also deduces theoretically that the interfacial tension α_{12} is equal to the difference of the surface tensions against the air of both superposed liquid layers $\alpha_1 - \alpha_2$ in equilibrium, a deduction which is in agreement with experiment. Two superposed layers in equilibrium must be regarded as solutions in the same solvent, and they must contain an equal number of molecules per unit volume (Avogadro's law). This latter fact is, however, only possible if there are phenomena of association in the solutions, that is, formation of complex molecules. The so-called univariant systems may be obtained without fulfilment of the requirements of the Phase Rule if the molecules of the component added combine with those in solution without increasing their number. A. F.

133. *A Method of determining Wind Velocity and Direction in the Upper Air by Sound.* **Bourgeois.** (Comptes Rendus, 167. pp. 769–772, Nov. 25, 1918.)—The usual method of determining wind velocity and direction in the upper air is by observations, with theodolites, of small rubber balloons filled with hydrogen, and rising at a known rate. This method fails on the numerous occasions when low cloud or fog interferes with good visibility of the balloon. The method now described consists in the registration by suitable apparatus of the direction of the sounds produced by a series of explosions of "crackers" carried by a balloon filled with hydrogen. The method thus substitutes sound registration for direct optical observation of the position of the balloon. The balloons used are just over 1 m. in diam., and the total weight of the "crackers" required for one ascent is about 200 gm. Yet the explosions can be heard and recorded up to distances of 15 km., in spite of winds of velocity greater than 10 m. per sec. R. C.

134. *The Hot Spell of August* 1918 *in North America.* **A. J. Henry.** (Monthly Weather Rev. 46. pp. 361–363, Aug., 1918.)—During the first ten days of Aug. 1918, the air temperatures recorded in the United States and Canada exceeded any on record there for the past 50 years. Mean max. shade temperatures registered during the three hottest days exceeded 100° F. over a wide area, and reached 104° to 106° in places. The author finds that the explanation of the abnormally high temperatures is to be found in the fact that for some time, as a result of the unhindered insolation that had been received at the earth's surface in the Plains States, the lower layers up to 1 km. had become unusually warm, while the development of a barometric gradient

for fresh southerly winds was associated with the transference of this heated air to the more northerly districts. R. C.

135. *The Theory of Lowitz's Arc and Allied Phenomena.* **S. Fujiwhara.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 502–515, Nov., 1918.)—In order to explain Lowitz's arc Pernter assumed crystals swinging about their mean position but remaining in the plane of the sun's vertical. The present author outlines a theory whereby the arc may be explained without limiting the plane of swinging in this way. By a further development various other halo phenomena of the same type which have been observed from time to time are also accounted for. J. S. Di

136. *On Slopes of Cloud-layers.* **R. Süring.** (Preuss. Akad. Wiss. Berlin, Ber. 38. pp. 814–820, 1918.)—The work of W. H. Dines, F. M. Exner, and others, has shown that conditions at heights of about 9 km. in the substratosphere exercise a great influence upon the variations of pressure recorded at the surface. As high clouds are often observed at that height, and as a cloud-layer may sometimes be supposed to mark a surface of equal pressure, an endeavour is made to measure the inclination to the horizontal of cloud-layers at that height. The apparatus used is Sprung's "Cloud Automat," a combination of two cameras both directed towards the zenith at about $1\frac{1}{2}$ km. horizontal distance from one another, with an electrical device for making simultaneous exposures at any desired moment. The apparent horizontal displacement of any portion of cloud from the one plate to the other is inversely proportional to the height of the cloud, and as an area of about 50 sq. km. at 10 km. can be shown on each plate, there may, on suitable occasions, be sufficient data on a pair of plates to determine the slope of the cloud-layer.

Slopes are found varying from less than 5° in 17 cases, between 5° and 10° in 22 cases, to above 10° in only 5 cases. The maximum was a slope of 18°, measured in a cirrus-wisp at 10 km. height.

The conclusions reached are that slopes of clouds across the direction of cloud motion are usually produced dynamically, and that secondary depressions can in such cases be developed at the surface. Slopes of cirrus sheets on their front sides are probably of thermal origin as a rule. R. C.

137. *On Warm and Cold Summers.*—**G. Hellmann.** (Preuss. Akad. Wiss. Berlin, Ber. 39. pp. 891–907, 1918.)—A new method of climatological classification of summers is developed and applied to the long series of observations at Berlin. In the last 90 years in which extremes of temperature have been determined by maximum and minimum thermometers, the hottest summers were those of 1834, 1868, 1911, and the coldest were those of 1840, 1844, 1871, 1913, 1916. The conditions favourable for hot summers are very similar to those favourable for cold winters. R. C.

138. *Physics of the Air.* **W. J. Humphreys.** (Frank. Inst., J. 184. pp. 137–178, Aug., 1917, and succeeding issues to Oct., 1918.)—These papers form a modern treatise on the physical phenomena of the earth's atmosphere. They contain the long-established principles of the subject and much of the important recent work in theoretical meteorology, a great part of which is scattered in numerous books and journals. An idea of the subjects dealt with may be obtained from the titles of the subdivisions, which are as follows:—Meteorological observations; Some theoretical temperature rela-

tions of the atmosphere ; Observed vertical temperature gradients ; The isothermal region or stratosphere ; Composition of the atmosphere ; Insolation ; Atmospheric circulation ; Barometric fluctuations ; Evaporation and condensation ; Fogs and clouds ; The thunderstorm ; Atmospheric electricity. The chapters on atmospheric circulation and the thunderstorm are very full. The work is copiously illustrated by numerous maps, diagrams, sketches, and photographs ; there is a good collection of photographs of clouds. An appendix gives a complete table of gradient wind velocities for cyclonic and anticyclonic movements and for different latitudes, the correction for curvature of the path of the air being included in the main table. R. C.

139. *Electric Underground Tide, derived rom Ocean Tides.* **M. Dechevrens.** (Comptes Rendus, 167. pp. 552–555, Oct. 14, 1918.)—Making use of the underground iron water and gas pipes supplying the St. Louis Observatory, Jersey, the author finds regular variations in the current indicated, with semi-diurnal maxima and minima, the period being lunar (24 hours 50 minutes covering two maxima and minima on an average). The maximum is associated with low tide. The annual minimum takes place two hours before the highest spring tide. Other features of the variation of ocean tides are also reproduced. The author concludes that similar effects should be found at all coastal stations. W. W. B.

140. *Constitution of the Earth's Interior.* **R. D. Oldham.** (Nature, 102. pp. 235–236, Nov. 21, 1918. Synopsis of discussion at British Assoc. Geophys. Com., Nov., 1918.)—Three distinct divisions are recognisable in the earth's interior :—(1) The outer solid crust of high permanent rigidity and of thicknesses $\frac{1}{2}$ to 1 % of the radius, but subject, from unknown causes, to mass movements and deformations in which displacements of as much as 10 miles vertically and 100 miles horizontally have occurred. (2) A shell about half the thickness of the radius with high rigidity for stresses of duration up to the order of tidal action, but of low rigidity to long-continued stress, at least in the outer portion. (3) A central nucleus of low rigidity for stresses of even a few seconds' duration. The data for conclusions (2) and (3) are derived entirely from records of earthquake waves, which show that the transition from (1) to (2) is sufficiently abrupt to reflect elastic waves, while that from (2) to (3) is far more gradual, and lies at a distance from the earth's centre of 0·4 to 0·5 of the radius. G. W. DE T.

141. *Bore-hole Temperature Measurement.* **J. Johnston** and **L. H. Adams.** (Economic Geology, 11. pp. 741–762, Dec., 1916.)—Methods of measurement by mercury thermometer, electro-resistance, and thermo-electric elements are minutely discussed. Full practical details, method of procedure, and relative accuracies are given. Mercury thermometers under best conditions only give an accuracy of $\pm 0{\cdot}1$ deg. C. ; electrical methods are, however, accurate to $\pm 0{\cdot}01$ deg. C., and require only one-third the time for an observation. No reading should be taken until 24 hours after the raising of the boring tool. W. A. R.

142. *Photomicrographs of Snow Crystals and Methods of Reproduction.* **W. A. Bentley.** (Monthly Weather Rev. 46. pp. 359–360, Aug., 1918.)—The author's photomicrographic reproductions of snow crystals have been criticised by G. Hellmann on the ground that they have been touched up and the outlines thus rendered untrue. The method of touching up is here

described and illustrations are given of photographs before and after treatment in order that the reader may judge of the desirability or otherwise of the process. The difficulties met with in the work of producing photomicrographs of snow crystals and the methods of overcoming them are described.
J. S. Dr.

143. *Earthquake Frequency.* **T. Terada.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 515–522, Nov., 1918.)—A preliminary investigation of the frequency of different intervals between successive earthquakes. This is a new way of approach to earthquake distribution; the usual method being to count the number of occurrences in a chosen unit of time. Under constant tension various materials undergo a time effect proportional to the logarithm of the time, and therefore this is taken as the independent variable instead of the time. The probability of y lying between y and $y + dy$ for statistics of several earthquakes resembles the Gaussian normal curve. Certain deviations, which cannot be accounted for by the simple theory of probability, may be explained if the probability of occurrence is dependent somewhat on the occurrence of previous shocks. W. A. R.

144. *Antarctic Ice-cap.* **D. Mawson.** (Nature, 102. pp. 315–316, Dec. 19, 1918. Paper read before the Geol. Soc., Nov., 1918.)—Much of the foundation of the ice-cap is elevated land, but elsewhere its floor is below sea-level. The ice surface masks a very irregular rock basement, and the ice thickness is, therefore, variable, and may reach several thousand feet. The mechanics of the flow and abrasion of so large a mass is different from that of smaller flows. The static pressure at the base may reach one ton per sq. in., and the accumulation of ground-heat may raise the temperature considerably above that of higher zones. When, therefore, ice is very thick a plastic base must be admitted. Where the supply is less than the destruction at the sea front, the ice boundaries are approximately the true coast line. Exceptions to this prevailing condition are the Great Ross Barrier and the Shackleton shelf, where the overflow from the land maintains itself as a thick floating structure extending far out to sea, and known as "shelf-ice." At the present rate of advance, ice at the sea face must have left the centre during the seventh century. W. A. R.

145. *Volcanic Eruptions and Solar Radiation Intensities.* **H. H. Kimball.** (Monthly Weather Rev. 46. pp. 355–356, Aug., 1918.)—In earlier papers curves showing mean monthly values of solar radiation at the earth's surface expressed as a percentage of the normal have been published for the years 1883–1912. The present paper continues the records up to 1918. The chief outstanding features are marked depressions in the curve following the eruptions of Krakatoa in 1883, Pelée in 1902, and Katmai in 1912. Complete recovery of the curve was not attained till 34 months after Krakatoa, 17 months after Pelée, and 21 months after Katmai. J. S. Dr.

146. *The Nitrogen Compounds in Rain and Snow.* **F. T. Shutt** and **R. L. Dorrance.** (Roy. Soc. Canada, Trans. 11. pp. 63–72, June–Sept., 1917.)—The paper summarises the results of ten years' work on the nitrogen compounds brought to the earth by rain and snow at a station near Ottawa. A total of 65·8 lbs. of nitrogen per acre was furnished in this way in the ten years, made up of 34·1 lbs. in the form of free ammonia, 10·1 lbs. of albuminoid ammonia and 21·6 lbs. of nitrates and nitrites. The rain was

caught in a tray 60 in. by 30 in. Every separate fall of rain of more than 0·01 in. was analysed, while in the case of continuous precipitation measurements were made twice a day. During a period of severe drought when bush fires were prevalent in the neighbourhood the scanty rain was particularly rich in free ammonia. Rain was found on the average to be approximately twice as rich as snow in nitrogen compounds, but the individual samples showed more variability with rain than with snow.

J. S. Di.

147. *Some Special Forms of Haloes.* **A. F. Hunter.** (Roy. Astron. Soc., Canada, J. 12. pp. 427–436, Nov., 1918.)—A general discussion of the method of formation of haloes with notes on some of the more prominent forms seen by the author during the past 30 years. Of the halo phenomena usually described in text-books some are due to reflection from the surfaces of ice crystals and some to refraction through the crystals. The large horizontal circle and sun-pillars are examples of the first type ; the 22° and 46° haloes, of the second. The summer is found to be the most favourable season for coloured haloes, the layer of small ice crystals being then thinner than in winter. A thick layer tends to overlapping of the spectrum colours and thus to a white halo. It is suggested that haloes are in some way linked with auroral phenomena. J. S. Di.

148. *Scattering of the Sun's Light by Irregular Refraction.* **L. S. Ornstein and F. Zernike.** (K. Akad. Amsterdam, Proc. 21. 1 and 2. pp. 115–118, 1918.)—J. Spijkerboer, in a recent dissertation, has confirmed a suggestion made by W. H. Julius [Abs. 98 (1910)], that in addition to the scattering due to molecules, scattering by irregular refraction due to accidental gradients in optical density must affect the distribution of luminosity of the sun's disc. The authors point out that the intensity of light in a beam subject to such gradients contained within a section of given length l of a cone with conical angle $d\omega$, and with its axis making an angle α with the direction of incidence may be represented by a function $\gamma(\alpha)d\omega$, which is of perceptible value only for very small values of α, and the integral of which over a sphere of unit volume is, by the definition of γ, equal to unity. This leads at once to an integral equation for the intensity of radiation, which can be transformed into a differential equation by the condition that γ is of sensible value only for small values of α. The diffusion is then found to be determined by the ratio α^2/l where α^2 is the average value of α^2. And this magnitude is specific for the problem, since α^2 is proportional to l. G. W. de T.

149. *Extent and Composition of the Atmosphere : Aurora, Fireballs, Meteors.* **A. Véronnet.** (Comptes Rendus, 167. pp. 636–638, Oct. 28, 1918.)—In a former paper [see Abs. 24 (1919)] the author dealt with the limits of an atmosphere of oxygen, nitrogen, or hydrogen for earth, moon, and planets. He now considers the actual case of a mixture of these three elements with argon, studying the way in which their proportions vary with height, and giving a table of density, first at ground level, 10, 30, 50, 70, 100, 150, 200, and 300 km. and secondly for the specially interesting layer, at every 10 km. from 100 to 200 km.

Oxygen rapidly diminishes with height, and argon more rapidly still, but nitrogen increases for more than 100 km. and is very important from 100 to 150 km. To this the author attributes the green auroral line as this is the auroral region. He deals with the enormous temperature effect of a

collision upon a minute meteor, and accounts in this way for the phenomena of fireballs and meteor trains, concluding that the region from 100 to 150 km. above the ground is that of incandescence for these objects. W. W. B.

150. *Simultaneous Variations in Solar Radiation and Spectroscopic Determinations of Solar Rotation.* **R. E. De Lury.** (Roy. Astron. Soc. Canada, J. 12. pp. 437–441, Nov., 1918.)—Having suggested that apparent changes in solar rotation velocity are not real, but are caused by atmospheric haze [see Abs. 108 (1917) and Abs. 25 (1919)], the author desires special simultaneous observations of rotation and radiation, but as a preliminary gathers together all the available material for comparison obtained at different observations, the radiation determinations beginning in 1883 and the spectroscopic determinations of rotation with Dunér's work at Upsala in 1887 and following years. He finds a rotation value of 2·03 km. per sec. for higher radiation values (101 % of average) and 1·97 km. per sec. for lower values (95 %). He notes the effect of the West Indian eruptions in 1902, and of Katmai in 1912, readily attributable to haze, and concludes that so far as the evidence goes his "haze" explanation holds good. W. W. B.

151. *Spectroscopic Measures of Solar Rotation.* **R. E. De Lury.** (Roy. Astron. Soc. Canada, J. 12. pp. 442–446, Nov., 1918.)—The author describes a new method of studying the solar rotation, comparing not only east limb with west, but also points midway between centre and east limb and between centre and west limb. An arrangement of prisms enables nine different strips of spectra to be simultaneously produced close to each other, as follows: N., E., S., and W. limbs; the two half-way points ME. and MW.; and three near centre—one the centre itself and the others 2 mm. N. and S. respectively. The last two may be used either with or without iodine absorption, and the electric arc may be substituted for ME. or MW. With so many reflecting prisms it is necessary to be very accurate in the determination of the tilt of the spider line in the micrometer. Clearly the method will allow a direct comparison between simultaneous determinations from the points E., W., and the points ME. MW., the effect of haze being greater for the limbs than for the midway points, and many such comparisons have been made. The results so far confirm the author's "haze" explanation, but more are wanted at all positions from centre to limb.
W. W. B.

152. *Total Solar Eclipse, June 8, 1918.* (Nature, 102. pp. 89–90, Oct. 3, 1918.)—From Washington State to Florida the sky along the line of totality was generally cloudy, but observers were lucky. The Lick party at Goldendale, Washington, had a perfectly clear gap on an otherwise very cloudy day, lasting from one minute before totality to a few seconds after the end of totality. Very fine photographs were obtained with a 6-in. lens of 40-ft. focus, showing sheaths of streamers round the chief prominences, and W. W. Campbell is convinced of the reality of the connection of the two phenomena with a single cause. Special cameras were used in an attempt to test Einstein's theory by photographing bright stars near the sun. A 3-prism spectrograph was used to obtain an accurate measure of the wave-length of the green coronium line λ5303. Five observers attended to shadow-bands, obtaining fairly consistent results, and Campbell attributes the phenomenon to atmospheric temperature or density gradient, having an effect similar to diffraction. Strong polarisation of the corona was recorded to a distance greater than the solar diameter.

The Mount Wilson observers at Green River, Wyoming, were less favoured, as the sun was partly covered with clouds during totality, but some fairly successful photographs were obtained. The green coronal line showed signs pointing to possible complexity had the photograph been taken under better conditions. The Yerkes party in the same locality had an extensive programme modified by cloud. The moving-picture camera for recording changes in the chromospheric spectrum at both ends of totality, took 16 pictures per sec., many of which were successful.

The Lowell Observatory station near Syracuse, Kansas, also had the sun covered with thin cloud. The green coronal ring was photographed without a slit, and its irregularities are shown to have no relation to those of hydrogen and helium, so that there is no obvious correlation between prominences and inner corona.

Successful expeditions were made by several other observatories, but the only permanent observatory in the region of totality, the Chamberlin Observatory at Denver, had the sky densely clouded. W. W. B.

153. *Parallax of Some Stellar Clusters.* **W. J. A. Schouten.** (K. Akad. Amsterdam, Proc. 20. 8. pp. 1108–1118, and 21. 1 and 2. pp. 36–47, 1918.)—Kapteyn's luminosity curve gives a relation between mean magnitude and diameter of stars. By means of this the author, having in a previous paper determined the parallax of two well-known clusters, Messier 3 and *h* and χ Persei, in the present paper gives details of similar investigations into some more clusters.

Cluster.	Parallax.	Probable Error.
Small Magellanic Cloud	0·0007″	± 0·0002″
Præsepe	0·024	± 0·004
Messier 46	0·002	± 0·0001
„ 52.....	0·002	± 0·0003
„ 37.....	0·002	± 0·0004
„ 36.....	0·005	± 0·001
20 Vulpuulæ.....	0·005	± 0·001
Messier 5	0·0005	± 0·0002
„ 13	0·00075	± 0·00006
„ 11	0·00055	± 0·00003
„ 67	0·001	± 0·0007

The last few do not agree perfectly with Shapley's determinations, and there is some discussion of the significance of the differences. The two parallaxes of the preceding paper, eleven parallaxes of the present paper, and Kapteyn's determination for stars in the neighbourhood of the sun are plotted in a diagram, and the general resemblance is held to justify Kapteyn's method. The author hopes by using much more material to derive conclusions as to the distribution in space of the clusters and test the theory of giant and dwarf stars. W. W. B.

154. *Experimental Eddy in a Closed Vessel; Application to Planetary System.* **E. Belot.** (Comptes Rendus, 167. pp. 678–680, Nov. 4, 1918.)—The experiments of Weyher, in reproducing waterspouts, and other phenomena of attraction, do not allow the study of "translation in rotation" of aerial eddies, hence the present experiment for that purpose. A bottle filled with water is rotated rapidly in a horizontal position about a parallel horizontal axis with a speed of five revolutions per sec., and it is seen that no

internal rotation takes place. The introduction of a few air-bubbles (20 cm.^{3}) brings about centrifugal rotation inside the bottle in the same sense as the forced rotation, and a physical eddy-system results. The bottle is then suddenly turned to a vertical position and the phenomena noted. Various devices are mentioned for emphasising the appearances, such as the case of a drop of oil and of froth of white of egg. An important deduction is that these eddy-systems are more stable when the axis is perpendicular to the plane of motion, *i.e.* while the bottle is still horizontal. By analogy with the solar system the author accounts in this way for the great mass of Jupiter among the planets since his obliquity is very small, as compared with those of the earth and Saturn for instance. He also suggests that the same theory will account for the exceptionally large relative size of our moon; and is inclined to attribute this not to any breaking off from the earth, but to the proportionately greater power of picking up cosmical matter, which by his theory the moon possesses, due to its small obliquity. W. W. B.

155. *Nova Aquilæ Observations in India.* **J. Evershed.** (Nature, 102. pp. 105–106, Oct. 10, 1918.)—Priority is claimed for G. N. Bower, of Madras, who noted the nova at 4.30 p.m. Greenwich time, on June 8. Comparing the spectrum with that of Arcturus, the author finds on June 12 and 13 many of the absorption lines in the nova duplicated, and two series of hydrogen absorption lines, both very much displaced towards the violet, giving velocities of approach 2700 km. per sec. for the wider, more refrangible series in H_β, H_γ, and H_δ, and for the narrow, less refrangible series 1720 km. per sec. In later plates the more rapid series disappears and the other series increases its speed by June 19 to 186 km. per sec.; indicating the action of a repulsive force. W. W. B.

156. *Theories of Temporary Stars.* **H. Macpherson.** (Observatory, 41. No. 532. pp. 399–403, Nov., 1918.)—A comparative sketch of the progress of speculation and inference on this subject, from the early pre-spectroscopic suggestions of Tycho Brahe, Herschel, and Zöllner, to the present day. Of the three main groups, binary star theories, collision theories, and "star and nebula" theories, after tracing the modifications made in each by successive investigators, the author maintains that the last-named group, generally referred to as Seeliger's hypothesis, is the most probable, but he indicates certain serious difficulties in connection with novæ, planetary nebulæ, and Wolf-Rayet stars from the point of view of evolution. W. W. B.

157. *Dwarf Stars.* **A. C. D. Crommelin.** (Scientia, Nov., 1918. Nature, 102. p. 292, Dec. 12, 1918. Abstract.)—Stars, small in volume but not necessarily in mass, may outnumber all other stars by three to one, but being too faint to be seen at a great distance, few are known to us. The paper gives details of a few of these, especially Barnard's "proper motion" star in Ophiuchus, with its parallax of half a second of arc and annual proper motion of ten seconds of arc, which is approaching us with such a velocity (100 km. per sec.) that its proper motion in arc is sensibly increasing. Its brightness is only 1/2000 of the sun, and the author conjectures that its surface brightness may be 1/170 that of the sun. W. W. B.

158. *"Positive on Negative" Method of measuring Spectra.* **J. Evershed** (Observatory, No. 533. pp. 443–445, Dec., 1918.)—The author gives his reason for believing that the method of superposing positive and negative of east-

and west-limb spectra for determining the star rotation, is not only a great refinement on the ordinary mode of measurement for that purpose, but is also applicable to other spectroscopic investigations concerning very small displacements. He finds it practically necessary to risk injury by having the films in actual contact, though devices for forming virtual images have been tried. He considers the limit readily attainable by his method to be 0·001 Å. ; so much so that very slight defects in the photographic films are noticeable drawbacks, only to be avoided by measuring several plates. Some very slight deviations of solar lines he attributes to movements of solar gases, and suggests a new field for observation of these. He also recommends the method for investigating the shifts, not yet fully explained, which iron arc lines show when more than one element is carrying the current in the arc.

W. W. B.

159. *Spectra of Binary Stars.* **R. G. Aitken.** (Pop. Astron. 26. p. 635, 1918. Nature, 102. p. 314, Dec. 19, 1918. Abstract of paper read before the Am. Astron. Soc.)—A comparison of 3919 close double-stars, including nearly all down to 8·5 mag., with the (unpublished) new Draper Catalogue of stellar spectra. The 605 spectroscopic binaries known up to Oct. 1917 are also compared, and the result shows that while the highest percentage of the spectroscopic binaries is shown among blue stars, that of the visual binaries is well distributed in intermediate classes, but avoids both the blue and red extremes. W. W. B.

160. *Variation in Light and Colours of RS. Boötis.* **F. H. Seares** and **H. Shapley.** (Mt. Wilson Solar Observat., Contrib. No. 159. Astrophys. J. 48. pp. 214–240, Nov., 1918.)—The discovery of this star's variability, of a type similar to that of short-period variables in globular clusters, but till then known in few other stars, suggested the advisability of special concentration on this object at Laws Observatory. In about 3 years 542 visual observations were made, mostly with an equalising wedge-photometer, using two comparison stars, one of which was of a magnitude intermediate between the maximum and minimum of the variable. Equality with this star is taken as giving a more accurate period than maximum or minimum. The long series ending in July 1910 was supplemented by observations on three nights in July 1914, so that the accuracy of the period is increased very considerably, the uncertainty being reduced to $\pm 0{\cdot}003$ sec. The colour-curve is shown to vary in harmony with the light-curve. Full details are given of photographic observations on three nights in July 1914, which are compared with the corresponding photo-visual observations on the same nights. Reduction is made to international zero point and comparison given with spectroscopic results. The amplitude of the photographic variation is 1·78 times that of the visual, and the colour-index varies continuously from $-0{\cdot}15$ mag. at maximum to $+0{\cdot}52$ mag. at minimum. An inference drawn from comparison with spectrograms by Pease is that the colour variation in Cepheids is correlated more closely with the hydrogen lines than with the general spectrum.

W. W. B.

161. *Conditions inside a Star.* **A. S. Eddington.** (Astrophys. J. 48. pp. 205–213, Nov., 1918.)—Dealing with giant stars of such low density as to behave like a perfect gas, and taking radiation-pressure into consideration, the author finds it possible to simplify his equations on the assumptions that the absorption coefficient does not vary throughout the star, and that the rate

of outward flow of energy is proportional to gravitation. With the aid of Emden's solution of a problem involving a similar quadrature, he arrives at the definite conclusion that "the luminosity (or more strictly the total radiation) of a giant star is, for a given mass, inversely proportional to its opacity and is otherwise independent of its density or stage of evolution," or in other words, "for stars of the same mass, the effective temperature is proportional to the sixth root of the density." This explains the small range of absolute luminosity of giant stars of all spectral types, provided that the opacity is the same. Adopting a molecular weight of 2·8, on stated theoretical grounds, the author finds the absolute magnitudes for stars of masses ranging from $\frac{1}{2}$ to 13 times that of the sun, showing for the F and G stars in Adams and Joy's list the small range of 0·7 to 1·6 times that of the sun. Further inferences are drawn: (1) That this small range of mass is due to the overpowering effect of radiation-pressure; (2) that this effect is due to the stars being exceedingly opaque to radiation, and (3) that this radiation within the stars must be of very short wave-length, like X-rays. The first of the two assumptions referred to above appears to be justified by the results, but the ratio of outflow of energy to gravitation is not quite constant, seeming to increase slowly towards the centre. The paper concludes with a table of density and temperature within a typical giant star of mass 1·5 times that of the sun, showing a great condensation of density towards the centre.

W. W. B.

162. *Luminosity in Globular Clusters.* **E. Hertzsprung.** (Astron. Nachr. No. 4953. Observatory, No. 533. pp. 449–450, Dec., 1918. Abstract.)—Globular clusters are at a distance of the order of 10,000 parsecs, so that only the very bright stars can be visible to us; hence studies of the distribution have been mainly based on these. The author has a method of measurement for the fainter stars also, in order to test the generality of this distribution. Putting the stars out of focus to reduce the local brightness, he is enabled to map out the total effect of the stars in any direction, and then subtracting the known effect of the bright stars, obtains the amount and distribution of the light of the fainter ones. This method he applies to M.3 (Canum Venaticum), and in the result the faint-star distribution agreed with that of the bright stars. The total photographic light of the cluster he finds to be 7·17 mag., half of it from within a radius of 50″, *i.e.* within a radius of $2\frac{1}{2}$ parsecs, if the distance of the cluster be taken as 10,000 parsecs. He infers that in this cluster the concentration of light is 10,000 times greater than in the region of the sun. The Hyades cluster has total light of 1/250 of that of M.3.

W. W. B.

163. *Radial Velocity of 2 ω Leonis.* **E. B. Frost.** (Astrophys. J. 48. pp. 258–260, Nov., 1918.)—Criticises one of the plates used in deducing the variable radial velocity, and accepts G. S. Monk's explanation that the plate must have been exposed to 3 Leonis in error. The recorded change of velocity is thus reduced from 20 to 11 km.

H. F. H.

164. *Preliminary Note on 66 Eridani.* **E. B. Frost.** (Astrophys. J. 48. p. 260, Nov., 1918.)—This binary star (R.A. 5h. 2m., decl. −4° 47′, magn. 5·2, spectrum Ao), with extreme separation of components of about 240 km. per sec., has a period of closely 5·52 days, the motion of the system being about ±30 km.

H. H. H.

165. *Orbit of Spectroscopic Binary* 19 *Lyncis.* **W. E. Harper.** (Roy. Astron. Soc. Canada, J. 12. pp. 395–396, Oct., 1918.)—Gives the elements of this star from 37 plates secured at Ottawa Observatory in 1915–18; the period is 2·2596 days. The lines of the secondary are too weak to obtain the ratio of the masses of the two bodies. 19 Lyncis, R.A. 7h. 15m., decl. + 55° 28′, magn. 5·6, type B.8, was announced a spectroscopic binary by Adams in 1911. H. F. H.

166. *Constitution of the Sun's Nucleus and Atmosphere.* **A. Véronnet.** (Comptes Rendus, 167. pp. 722–725, Nov. 11, 1918.)—A previous paper [Abs. 24 (1919)] dealt with masses of homogeneous gas. This extends the investigation to mixtures, ignoring the small difference between coefficients of dilatation and compressibility. Under a pressure of 1500 atmos. the gases reach a density one-third of their limiting density, giving a sudden point of inflection in the density curve and suggesting a surface of separation between the main body of the sun and its lighter envelope. With his previous value of 1·41 for density and 6000° C. for temperature he finds a mean atomic weight for the nucleus (supposed diatomic) of about 110, nearly that of silver. Then assuming a mixture of 40 % Ag, 30 % Ta, and 10 % each of Fe, Ca, and Na, in order to reproduce exactly his theoretical atomic weight he investigates the change of density with depth, finding the density doubled at about 2 km. and nearly 99 % of its central value at 100 km., corresponding to a depth of 1 km. on the earth; at greater depths than this the density is therefore practically uniform. In the atmosphere it is very different. The density is halved at a height of 2 km. and reduced to only 1 % at 30 km. The heaviest vapours (Pt, Au, Hg, etc.) cease to have any effect at 20 km., and the silver group (Ag, Cd, Sn, etc.) towards 30 km.

Thus in passing from a height of 20 km. to a depth of 10 km. in reference to the suggested surface, the density increases 110-fold, or from a gaseous to a liquid value, confirming the definiteness of the separating surface, and making it analogous with that of the earth. Now, our clouds hang lower in winter, when convection is less active. So the author suggests that on the sun, if its temperature were lowered, a similar effect would take place, and if the vapours fell so low as 20 km. the heavy gases would appear, and the sun's light having to traverse a layer eight times as dense would look red and much less bright. So also when its temperature was higher it might have been a white star.

Accepting the author's figures it seems that the sun's atmosphere, at any rate above the 100-km. limit, is practically all hydrogen. W. W. B.

LIGHT.

167. *The 72-inch Canadian Reflecting Telescope.* **J. S. Plaskett.** (Roy. Astron. Soc. Canada, J. 12. pp. 397–410, Oct., 1918.)—The director of the new Dominion Observatory near Victoria, B.C., gives an account of the erection of the dome and of the great new reflector, the grinding and polishing of the mirror, its testing and installation and its first performance.

The central hole in the mirror glass, which weighed nearly two tons before the figuring began, was found to be a drawback during the polishing process, and it is recommended that in such cases a plate of glass should be cemented into the hole so that there should be a continuous surface until the polishing and figuring is completed.

The installation was carried through very quickly, a star spectrum being photographed only a week after the mirror reached Victoria. The instrument, with 72-in. aperture and 108 ft. focal length, when used as a single-prism spectrograph, gives a linear dispersion near H_γ of about 35 Å. per mm. and under average conditions will photograph the spectrum of a 7th magnitude star in less than 25 minutes. Precautions are adopted against temperature-changes, which, although the range of temperature is small, will affect an instrument of so great a size.

The director speaks highly of the mechanica. and optical parts of the instrument, which so far has exceeded expectation. There is very little loss of time between exposures on different objects, and 22 spectra have been photographed in less than 7 hours, none brighter than 6th magnitude. The great desideratum now is a largely increased staff, to prevent the accumulation of photographs beyond the capacity of measurement and reduction.

W. W. B.

168. *Interferometers for the Examination of Optical Systems.* **F. Twyman.** (Phot. J. 58. pp. 239–252, Nov., 1918.)—An account of the interferometer previously described [see Abs. 356 (1918)] with an example of the application of the same principle to the case of large-aperture camera-lenses. A special form of interferometer is used for this purpose in which are provided (i) a means of rotating the lens about a line at right angles to the axis and passing through its second principal point, and (ii) mechanism by means of which synchronously with this rotation the convex back reflecting mirror is automatically moved away from the lens in such a way as to correspond with the focal plane in which the lens is desired to form its image. J. W. T. W.

169. *Change of Phase in Light reflected from a Silvered Surface.* **R. S. Clay.** (Optical Soc., Trans. 19. pp. 140–141, Feb., and March, 1918.)—To obtain very light mirrors thin films of celluloid (obtained by dropping a solution of celluloid in amyl acetate on water and allowing it to spread by capillarity over the surface of the water) were silvered. The films thus obtained were so thin as to show colour, and in silvering them it was noticed that the coating of silver changed the colour into its complementary, so that, for instance, a streak of colour which appeared red on an unsilvered film would become green when the film was silvered. The phenomenon can readily be shown by a projection lantern. A. W.

170. *Reflecting Prisms.* **T. Y. Baker.** (Optical Soc., Trans. 19. pp. 113–119, Feb., and March, 1918.)—Discusses various types of reflecting prisms in which the reflections are all in one plane, the number of reflections being one, two, or three. A triple reflection prism of angles 30°, 30°, 120° is suggested as a substitute for the horizon mirror in a sextant, resulting in a considerably enlarged aperture. A. W.

171. *Detection of "Ghosts" in Prisms.* **T. Smith.** (Optical Soc., Trans. 19. pp. 120–134; Disc., 134–137, Feb., and March, 1918.)—Describes a method of detecting "ghosts" in prisms due to multiple reflections. A plane principal section of the prism is taken and developed in a plane by successive rotation about its sides in all possible ways. Straight lines will then determine every possible path for all rays in the prism. Applications of the method to isosceles and isosceles right-angled prisms, to pentagonal prisms and to others of less usual type are considered, and illustrative photographs are reproduced. A. W.

172. *Interferometry of Vibrating Systems.* **C. Barus.** (Nat. Acad. Sci., Proc. 4. pp. 328–333, Nov., 1918.)—Describes experiments on the interference fringes seen when the two mirrors giving the interfering beams are vibrated by telephone magnets operated in series or in parallel. With the apparatus used, currents of less than 10^{-6} amp. could be detected, and it is considered that the sensitivity of the method could be greatly increased by the use of lighter moving parts. J. W. T. W.

173. *Correction of Lenses for Coma.* **E. Carvallo.** (Comptes Rendus, 167. pp. 641–644, Oct. 28, 1918.)—Gives a new method of demonstrating Seidel's equations without introducing the sine condition. Further, an expression is obtained for the coma when the aberration along the axis is not zero. [Errata. *Ibid.* p. 740, Nov. 11, 1918.] J. W. T. W.

174. *Dispersion.* **R. Lundblad.** (Ann. d. Physik, 57. No. 3. pp. 183–202, Oct. 29, 1918.)—A mathematical paper dealing with fundamental quantities in the theory of optical dispersion. A. W.

175. *Elementary Theory of Atmospheric Reflections.* **A. Wegener.** (Ann. d. Physik, 57. No. 3. pp. 203–230, Oct. 29, 1918.)—A simple quantitative theory is given of mirage and similar atmospheric optical phenomena due to reflections at surfaces of density inversion or discontinuity. Numerical results of the theory are given in tabular form. R. C.

176. *Dispersal of Light by a Dielectric Cylinder.* **Rayleigh.** (Phil. Mag. 36. pp. 365–376, Nov., 1918.)—The paper is devoted to the development of expressions obtained by him in 1881 [Sci. Papers, 1, p. 553] into a form suitable for numerical computation, for which purpose they are expressed in terms of the usual Bessel functions, and of the nearly allied G-functions tabulated in the B. A. reports of 1913 and 1914. Tabulated results of the computations are given for the refractive index 1·5 and for ratios of the cylinder circumference to the wave-length in air 0·4, 0·8, 1·2, 1·6, 2·0, 2·4; and also a number of plotted curves. The author points out that neither Seitz [Abs. 1275 (1905)] nor Ignatowsky [Abs. 134 (1906)], who corrects some of Seitz's results, appears to have been acquainted with his much earlier work. G. W. DE T.

177. *Cementing of Optical Parts.* **J. W. French.** (Optical Soc., Trans. 19. pp. 143–160; Disc., pp. 160–163, April, 1918.)—Discusses the merits and defects of Canada balsam as a cementing agent for optical elements, and gives a number of methods used for the purpose. Photomicrographs are given to illustrate the different ways in which a start may develop in the case of glass surfaces cemented with Canada balsam. In the *discussion*, **H. S. Ryland** recommended the use of hard Canada balsam with 4 % castor oil, and the varnishing of the edges, after cementing with shellac to avoid the penetration of damp. J. W. T. W.

178. *Relative Dispersion and Achromatism of Optical Glasses.* **F. E. Lamplough** and **I. M. Mathews.** (Optical Soc., Trans. 19. pp. 83–96; Disc., pp. 96–100, Jan., 1918.)—Gives the results of tests on the relative dispersion of different glases throughout the visible spectrum. It is found that glasses of different dispersions have, in general, very different relative dispersions at different parts of the spectrum, so that the elimination of the secondary spectrum by this means is not possible with the glasses at present available. A discussion of the shape of the relative dispersion curves, based on the electromagnetic theory, is given in an appendix. In the *discussion*, **T. Smith** gave the relation $(A^1 - D) + (F - G^1) = 1{\cdot}212\ (C - F)$ for the partial dispersions of glasses given in the Jena list. J. W. T. W.

179. *Interference Fringes developed by Rubbing and Electricity in Certain Anisotropic Liquids.* **F. Grandjean.** (Comptes Rendus, 167. pp. 494–496, Sept. 30, 1918.)—The author has observed that when an anisotropic liquid, such as axoxyanisole, anisole-phenetole, or phenetole is placed between two plates of different materials, and examined under the microscope with white light, coloured fringes are formed when the plates are caused to rub together. If the movement of the plates is stopped, the colours disappear very rapidly as a rule. The series of colours obtained is analogous to that of Newton's rings or to that of chromatic polarisation between parallel nicols. In monochromatic light a succession of dark and bright fringes is obtained. A similar effect is produced when the anisotropic liquid is examined on a glass slip in an electric field. Friction or electricity therefore can develop in certain liquids a peculiar structure such that when light traverses the liquid it suffers interferences and passes out coloured. The experiments are described without the author seeking to put forward any special hypothesis. A. F.

180. *New Proof of the Existence of Molecules.* VI. *Absorption of Light by Molecular and Colloidal Solutions of Sulphur.* **N. Pihlblad.** (Zeits. Phys. Chem. 92. pp. 471–495, Sept. 16, 1917.)—Continuation of the calorimetric and spectrophotometric measurements made by Svedberg and the author on solutions and disperse systems showing that with decreasing size of particles the light absorption approaches the values for molecular and ionic solutions. The experiments are now extended into the ultra-violet and cover the range $\lambda 250$ to 700 $\mu\mu$. Solutions of sulphur (hydrosols) were prepared in various ways, the most highly-disperse system being obtained after Wackenroder and Raffo, and fractionation of the solutions after Odén. The character of the absorption curves changes continuously with decrease in the size of particles, and the absorption in a molecular solution of sulphur (in ethyl alcohol) corresponds with that of a limiting colloidal solution. When the average diam. of the particles is 550 $\mu\mu$, the absorption curve is flat and a maximum

is not discernible ; with smaller particles the absorption becomes stronger, and the maximum at $\lambda 340\ \mu\mu$ for particles of $160\ \mu\mu$ diam. shifts to $\lambda 280\ \mu\mu$ for particles of $110\ \mu\mu$. The green-blue and violet dispersoids do not fit, as to light absorption, into the examined series of sulphur colloids, however, and their colour seems to be due to the existence of a different sulphur modification or of a sulphur compound. The investigation is to be continued.

H. B.

181. *Calculation of a Two-Lens Objective.* **K. Yamada.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 485–495, Oct., 1918.)—In continuation of a previous paper [see Abs. 1083 (1918)], the author proposes a method for the calculation of the four radii of an uncemented two-lens objective when the thickness of the component lenses is neglected and their interval is taken finite, the object being supposed at finite distance. Expressions are further found for the correction terms to the four radii, when the thickness of the component lenses and their interval are taken into consideration, the object being supposed at finite distance. J. W. T. W.

182. *Lens-Mirror Design.* **K. Yamada.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 495–500, Oct., 1918.)—Gives a method for calculating the correction terms for the radii of the surfaces of a lens-mirror of finite thickness. [See Abs. 1235 (1916).] J. W. T. W.

183. *A Statistical Survey of Colour Vision.* **R. A. Houstoun.** (Roy. Soc. Proc. 94. pp. 576–586, Aug. 1, 1918.)—It is well known that many people with slightly abnormal colour-vision exist, and this suggests a statistical method of treating colour-vision. If 1000 persons could be examined, and marks awarded for colour perception, and if, further, a curve were plotted relating the number of individuals in each class of proficiency to the number denoting the class, evidence on the validity of the Young-Helmholtz theory could be secured. If two maxima exist, a small maximum for the dichromats and a large maximum for the trichromats, this would support the theory ; but if only one maximum was found it would appear that colour blindness is not due to absence of one of three primary colour-sensations.

The author applied the method to 79 observers, of whom 38 were women. The method consisted in noting the number of separate colours discernible in the spectrum. The apparatus, which is a variant of that adopted by Edridge Green, is discussed in detail. The author can see 17 patches under favourable conditions, but acuteness in this respect depends to some extent on the intensity of illumination. The numbers recorded vary from 5 to 26. Two obviously colour-blind subjects are included, and four observers with exceptionally acute colour-vision could "see indigo." The diagram prepared from these data has two well-defined and nearly equal maxima in close vicinity but also gaps at the ends of the series. However, it would require a much larger number of observations positively to disprove the existence of separate maxima for dichromats and monochromats. J. S. D.

184. *Light Emitted from a Random Distribution of Luminous Sources.* **Rayleigh.** (Phil. Mag. 36. pp. 429–449, Dec., 1918.)—Recent researches have emphasised the importance of a clear comprehension of the operation under various conditions of a group of similar unit sources, or centres, of isoperiodic vibrations, *e.g.* of sound or light. The sources, supposed to be concentrated in points, may be independently excited (as probably in a soda flame), or they may be constituted of similar small obstacles in an otherwise

uniform medium, dispersing plane waves incident upon them. The present paper gives a mathematical investigation of an effect, such as the intensity, at a great distance from the cloud, either in a particular direction, or in the average of all directions. For convenience of calculation and statement sound vibrations are specially dealt with ; but most of the results are equally applicable to electric vibrations, as in light, the additional complication being merely such as arises from the vibrations being transverse to the direction of propagation. A. W.

185. *Further Extension of Sommerfeld's Diffractive Problem.* **F. J. W. Whipple.** (Phil. Mag. 36. pp. 420–424, Nov., 1918.)—Hargreaves' method [Abs. 1248 (1918)] can be adapted to the problem of diffraction of waves of arbitrary type. Assume the wave-fronts parallel to the diffracting edge and the disturbance to have lasted for a finite time only. Take rectangular axes, diffracting edge as z-axis and the y-axis perpendicular to the wave-fronts, the waves approaching from the negative side. Let c be the speed of propagation, t the time, and ω the distance from the diffracting edge. Then V, the measure of disturbance must satisfy $[\nabla^2 - d^2/c^2dt^2]\mathrm{V} = \Box\mathrm{V} = 0$ and $\mathrm{V} = \psi(ct - y)$ will represent the incident wave, where ψ is any continuous function such that for $t >$ some constant k, $\psi(-ct)$ and its derivatives vanish. Seek an expression suitable for representing the disturbance diffracted into a shadow—say $f = \int_1^\infty \psi(ct - y - u\xi)\,\mathrm{U}\,du$, where $\xi \equiv \omega - y$ and U is a function of u. Then it is easily verified that $\Box f = 1/\omega \int_1^\infty \{2(u^2 - u)\,\mathrm{U}\xi\psi'' - u\mathrm{U}\psi'\}\,du$, the integration of which can be effected by making the expression in the larger brackets a perfect differential, and then it is easily found that $= 1/\pi \int_0^\pi \psi(ct - y - \xi \sec^2 a)\,da$ will satisfy $\Box f = 0$, that if we make $\mathrm{V} = f$ in the shadow and $\psi - f$ outside $\Box\mathrm{V} = 0$ throughout space, giving the solution for waves approaching the screen and totally absorbed by it. Otherwise allowance must be made for the reflected waves, the necessary modifications being easily made. The condition of finitude of past time cannot, from the physical point of view, be fundamental, and it should be possible to modify the mathematics to allow for an infinite train of waves. In the most important case of a simple harmonic disturbance, the author shows that the solution reduces to Sommerfeld's and is therefore justified. He observes that "the result is of interest, not only as containing the first complete solution of a diffraction problem but also as showing that Fresnel's integrals, devised for an approximate solution of the problem, suffice for the complete one," an aspect of the subject discussed at length in Drude's *Optics*. G. W. DE T.

186. *Influence of "Ultra-red" Frequencies on the Refractive Index in the Visible Spectral Region.* **J. Wimmer.** (Phys. Zeits. 19. pp. 483–486, Nov. 1, 1918.)—Using Drude's theory and Dehlinger's experimental results in dispersion, the author calculates the effect produced by infra-red frequencies (characteristic absorption frequencies of the substances) on the value of μ in the visible region of the spectrum. Measurements were made in the case of the following substances, KCl, NaCl, CaF_2, SiO_2, H_2O, CS_2, the calculated and observed results being tabulated. A series of similar measurements were also made for various organic liquids.

The theoretical deductions appear to be justified. A. B. W.

187. *The Coupling of Electronic Rings and the Optical Activity of Asymmetric Molecules.* **A. Landé.** (Phys. Zeits. 19. pp. 500–505, Nov. 15, 1918.)—The paper commences with a discussion of previous work on the numerical relation between optical rotation and the atomic structure of molecules. Born's work is referred to [see Abs. 934 (1918)] on the general electronic theory of optically active crystals, and of iostropic and anisotropic fluids. The application of Born's formulæ to simple mechanical models is then described [see Abs. 1089 (1918)]. This points to a dependence of the rotation magnitude on the nature of the coupling and the configuration of the electrons in the molecule. The present paper is an extension of previous work, but based on the recent theories of atomic structure proposed by Bohr, Debye, Sommerfeld, and others. H. H. Ho.

188. *Polarisation of Light.* **F. v. Hauer.** (Ann. d. Physik, 57.2. pp. 145–160, Oct. 15, 1918.)—Deals with the polarisation of light in cloudy media, with special reference to the light from the sky. A. W.

189. *Ultra-violet Spectra of Hot Sparks in High Vacua.* **R. A. Millikan** and **R. A. Sawyer.** (Phys. Rev. 12. pp. 167–170, Aug., 1918. Abstract of paper read before the Am. Phys. Soc., April, 1918.)—Describes a special type of grating spectrograph designed for obtaining spectrograms in the extreme ultra-violet of high-potential sparks *in vacuo*. The sparking potential when the pressure of the residual gas is sufficiently low, for example, between 10^{-5} and 10^{-8} mm., may be as much as 150,000 volts per mm. With this spectrograph zinc spectra have been obtained which show about 60 lines in the region between λ2100 and λ900, the shortest wave-length obtained being 928 Å.U. A table is given of 57 lines, all of which have been measured on at least two plates. There is some indication of even shorter wave-lengths, though no positive proof as yet. Comparison of the spectra of different metals seems to show that the lines of shorter wave-length are not due to occluded gases in the metals, but rather, are characteristic of the metals themselves. A. W.

190. *Ultra-violet Spectra of Magnesium and Selenium.* **J. C. McLennan** and **J. F. T. Young.** (Phil. Mag. 36. pp. 450–460, Dec., 1918.)—The present paper makes a contribution to a systematic study of the spectra of the elements in the ultra-violet and Schumann regions. It was proposed to investigate the region between λ3000 and λ2000 with a Hilger quartz spectrograph, Type C, that between λ2200 and λ1850 with a Hilger quartz spectrograph, Type A, and that between λ2000 and λ1400 with a specially constructed fluorite spectrograph. The Schumann region to slightly below λ600 it was proposed to examine with a vacuum grating spectrograph recently designed and constructed for the Physical Laboratory at Toronto by Hilger. The results obtained with Si and with Cd have already been given [Abs. 1664 (1915)], and an account is now given of the work done so far with Mg and Se. With Mg the Type C spectrograph was used, and with Se the Type A spectrograph. The spectra of Mg for (*a*) the spark in air, (*b*) the arc in air, and (*c*) the arc *in vacuo*, were investigated in the region between λ2852·22 and λ2000, and in all some 58 new lines have been measured. The existence of the line λ2026, first measured by Saunders, has been confirmed, and considerations are brought forward which support the view that the series represented by $\nu = (1{\cdot}5, S) - (m, p_2)$ has a

real existence. Twelve new lines have been measured in the Se spark spectrum between λ2200 and λ1850, and five new lines between the same limits in the arc spectrum. In the sources used no part of the spectrum of longer wave-length than λ2200 was present. The absorption spectrum of Se metal in the carbon arc was investigated and a reversal was found at λ1960, which is the strongest line in both the arc and spark spectra. If the absorption of Se vapour should prove to be analogous to that of Hg, Zn, and Cd, this would indicate that the two series $\nu = (1{\cdot}5, S) - (m, P)$ and $\nu = (1{\cdot}5, S) - (m, p_2)$ for Se are both in the extreme ultra-violet. Photographs are reproduced. A. W

191. *Origin of Spectra.* **J. C. McLennan.** (Phys. Soc., Proc. 31. pp. 1–29, Dec., 1918. Guthrie Lecture.)—From the results of Bergen Davis and Goucher, combined with those of other investigators, it would appear to be generally agreed that with the vapours of such elements as Hg, Zn, Cd, and Mg, for example, the actual ionisation potentials are given by $V.e = (1{\cdot}5,S) \times h$, where (1·5, S) is the frequency of the shortest wave-length of the principal singlet series $\nu = (1{\cdot}5, S) + (m, P)$. It would also appear to be established that it is possible to cause a vapour bombarded in a vacuum by electrons to emit a radiation consisting of one wave-length only, provided *all* the bombarding electrons possess kinetic energy given by the quantum relation $Ve = h\nu$, ν being the frequency of the monochromatic radiation stimulated; moreover, by gradually increasing the speed of the bombarding electrons the vapour may be caused to emit at successive stages radiation of shorter and shorter wave-lengths, each particular wave-length being stimulated only when the bombarding electrons have attained velocities corresponding to its frequency as indicated by the quantum relation. All apparent departures from this view obtained in any experiments would appear to be explainable when account is taken of the fact that a Maxwellian distribution of velocities holds for streams of electrons thermionically emitted by incandescent metallic filaments. Detailed descriptions are given of a fluorite spectrograph and of a vacuum grating spectrograph, the first allowing measurements to be made as far as λ1400 and the second serving for the Schumann region as far as λ600 or a little beyond. [See Abs. 15 and 811 (1914), 778 and 779 (1917)]. A. W.

192. *Fundamental Frequencies in Spectra.* **J. C. McLennan** and **H. J. C. Ireton.** (Phil. Mag. 36. pp. 461–471, Dec., 1918.)—Experiments are described which show that when zinc and cadmium vapours respectively are bombarded by electrons whose kinetic energy is gradually increased, monochromatic radiation is suddenly emitted by the vapour when the impact voltage is that given by the quantum relation for the frequency $\nu = (1{\cdot}5, S) - (2, p_2)$. When the impact voltage was increased beyond this amount no additional radiation was observed until that corresponding to the frequency $\nu = (1{\cdot}5, S) - (2, P)$ was applied. When these conditions were realised the wave-lengths whose frequencies are given by $\nu = (1{\cdot}5, S) - (2, p_2)$ and $\nu = (1{\cdot}5, S) - (2, P)$ were then recorded on the plates. Other experiments have shown that when a Bunsen flame is fed with the vapour of heated zinc, it is possible to obtain monochromatic radiation of wave-length λ3075·99. All the evidence adduced goes to show that the series of lines given by $\nu = (1{\cdot}5, S) - (m, P)$ is probably fundamental from the point of view of electronic vibrations within the atoms of the elements Hg, Zn, Cd, Mg, and Ca, and probably also Sr and Ba. [See Abs. 1408 (1915).] A. W.

193. *Crystalloluminescence.* II. **H. B. Weiser.** (J. Phys. Chem. 22. pp. 576–595, Nov., 1918.) [See also Abs. 52 (1919).] From a survey of the literature, and experiments on the crystalloluminescence and triboluminescence of arsenic trioxide and potassium sulphate, the author concludes that triboluminescence, like crystalloluminescence, is caused by chemical action. In the case of substances which show both triboluminescence and crystalloluminescence, the chemical reaction and hence the colour of the luminescence are identical. The identity of the crystalloluminescence and triboluminescence of arsenic trioxide and of potassium sulphate has been shown photographically. The colour of the luminescence is specific, depending on the chemical reaction by which it is caused. A large number of substances exhibit the property of triboluminescence, but relatively few show crystalloluminescence. All the well-defined cases of the latter, are to be found among the simple inorganic salts. In the case of inorganic substances, the crystalloluminescence is due to the rapid re-formation of molecules broken up by the process of electrolytic dissociation; triboluminescence of the same substances is due to the rapid re-formation of molecules broken up by the violent disruption of crystals. All crystalloluminescent substances show the property of triboluminescence, but the reverse is not true. That all triboluminescent substances are not also crystalloluminescent is due to the fact that sufficient breaking up or disarrangement of the molecules (other than by ionisation in solution) is usually accomplished only by the grinding or crushing of crystals. Due to the conditions attending their formation, a state of strain may exist in certain newly formed crystals that will disappear with time. If outside force is applied to such crystals before the internal forces have become adjusted, the combined effect may result in a particularly violent disruption of the crystal with a correspondingly marked molecular decomposition and consequent triboluminescence. The intensity of triboluminescence varies widely in different substances. Two causes contribute to this, namely, the comparative forces necessary to break up the molecule in different cases, and the magnitude of the conversion factor for light in the luminescent reaction. **A. F.**

194. *Physical Characteristics of X-ray Fluorescent Intensifying Screens.* **M. B. Hodgson.** (Eastman Kodak Co.'s Research Lab., Comm. No. 67. Phys. Rev. 12. pp. 431–435, Dec., 1918.)—The experiments described are introductory to a general study of fluorescence produced by X-rays. Spectrograms of the fluorescences excited in various materials, in particular calcium tungstate, have been made under varying conditions. The fluorescence is shown to be primarily dependent on the following factors: (1) selective absorption of the elements of the crystalline compound in the intensifying screen, (2) the frequency of the existing radiation, and (3) the crystal structure of the particular calcium tungstate used. The author suggests that the X-ray analysis of the crystal structure of calcium tungstate will probably throw a great deal of light on the subject.

It has been shown that in a photograph made from a screen system, about 20 % of the exposure is due to the absorbed energy of the direct rays, the remaining 80 % being supplied by the screen fluorescence. In trying to shorten exposures by this method, the author has tried using the characteristic radiation from metal screens. Silver, Cu, Pb, W, and Pt have been used, Ag and Pt proving most effective. **A. B. W.**

HEAT.

195. *Thermo-oscillator.* **R. Kempf.** (Zeits. Instrumentenk. 38. pp. 163–168, Oct., 1918.)—Describes an electrical arrangement whereby a continuous oscillation of temperature between two limiting temperatures can be maintained for any length of time. When either limit is reached a relay is brought into operation which causes the temperature of the heating coil to progress towards the other limiting temperature. The arrangement is provided with a Pt-resistance thermometer, but mercury thermometers in steel capillary tubes can also be used. [See Abs. 1765 (1912).] A. W.

196. *The General Character of Specific Heats at High Temperatures.* **W. P. White.** (Nat. Acad. Sci., Proc. 4. pp. 343–346, Nov., 1918.)—The specific heats of three forms of silica and two silicates (alkaline felspars) determined for temperatures up to 1300°, indicate that the atomic heats at constant volume for these substances increase above the theoretical value, asymptotic to 5·96, as the heats of the metals have been known to do, and hence that such increase is a very general phenomenon, as has been suspected. A. F.

197. *Avogadro's Law.* **C. del Lungo.** (N. Cimento, 14. pp. 262–275, Nov.–Dec., 1917.)—Continuing his critical examination of the foundations of the kinetic theory of gases [*Ibid.* 12. pp. 215–230 (1916)] the author deals with Avogadro's law and the work of Clausius, Bryan, Gibbs, J. J. Thomson, Burbury, Maxwell, v. Lang, and P. G. Tait in relation to it. That a mixture of gases should present a superposition of two or more gases each at its own temperature is not physically inconceivable ; but this would contradict the Second Law of Thermodynamics. A. D.

198. *The Application of Planck's Extension of the Quanta Hypothesis to Rotating Bodies with Two Degrees of Freedom in a Directed Field.* **S. Rotszajn.** (Ann. d. Physik, 57. 2. pp. 81–123, Oct. 15, 1918.)—Given Planck's quanta theory and its later extension by Sommerfeld, Schwarzschild, and Epstein to conceptions with several degrees of freedom, it is of primary interest to treat various problems, which formerly had only received solution for one degree of freedom, from this extended standpoint. Such problems include the direct estimation of rotatory specific heats for bodies with two degrees of freedom and the supplementary cases for a directed field, *e.g.* the calculation of the susceptibility of paramagnetic bodies. The first problem has been treated by Planck [see Abs. 348 (1916)] and Epstein, the second by Weyssenhoff by a quanta method for the case of a single degree of freedom. In the present paper the solution is attempted for the second generalised problem, using the extended quanta method, *i.e.* the case for rotation about a fixed point. As singular surfaces the motions were chosen of plane orbits in the meridian and in parallel circles. The two degrees of freedom were accordingly regarded as incoherent. From these starting surfaces the complete structure of the phase-space is then stated.

The first essential physical result obtained is the formula for the rotatory specific heat for 2 degrees of freedom, namely :—

$$C_{2R} = Nk\sigma^2 \frac{d}{d\sigma^2} \log_e \sum_{n=1}^{\infty} ne^{-\sigma n^2},$$

which is quite new and superior to all similar formulæ hitherto proposed. In particular, the formula obtained by Planck for the coherent treatment of the same problem, namely :—

$$C_{2R} = Nk\sigma^2 \frac{d}{d\sigma^2} \log_e \sum_{n=0}^{\infty} (n + \tfrac{1}{2})e^{-\sigma(n+\frac{1}{2})^2},$$

is found to be inferior to the above. The previous introduction of the field serves as a means for the incoherent treatment, since, according to Planck's theory, there is no possibility for the application of quanta incoherently to the free rotating structure. Similarly the important result derived by Tetrode with respect to the rotation entropy of diatomic gases at high temperatures is given without trouble by the author's incoherent treatment. The quanta theoretical calculation of the magnetic susceptibility of paramagnetic bodies has likewise been evaluated from the author's standpoint of phase-space division. The formula obtained is :—

$$\chi = \frac{Nm^2}{h^2} \pi^2 J \frac{\frac{5}{4}e^{-\sigma} + \frac{1}{8} \sum_{n=1}^{\infty} \frac{e^{-\sigma n^2}}{n(n^2-1)}}{\sum_{n=1}^{\infty} ne^{-\sigma n^2}}$$

For low temperatures this affords a limiting value not zero, and for high temperatures gives the Curie-Langevin value $Nm^2/3kT$. An appendix is given dealing with the evaluation of complex integrals. H. H. Ho.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

199. *Atomic Structure of Electricity.* **R. Bär.** (Ann. d. Physik, 57. 3. pp. 161–182, Oct. 29, 1918.)—As a result of these experiments with a "Millikan" chamber the author concludes that the charges (or the reciprocals of the balancing potentials) of microscopic aluminium particles behave, within the limits of experimental errors, as integral multiples of a fundamental charge. For very small particles these multiples are the smallest whole numbers. E. H. B.

200. *Generalisation of Heaviside's Expansion Theorem.* **A. Press.** (Rev. Gén. d'Él. 4. pp. 691–693, Nov. 9, and **J. B. Pomey.** *Ibid.* pp. 693–694, Nov. 9, 1918.)—Starting with the differential equation with constant coefficients in its most general form $A_n\partial^n y/\partial x_n + \ldots A_1\partial y/dx = C + X$, where C is a constant and X is a function of X of which the constant term has been included in C, the former author imposes the condition $y = 0$ for $x < 0$ by the introduction of Heaviside's function U, which vanishes for all negative values of x and becomes $+1$ for all positive values, through the equation $C + X = C_0U + XU = (C_0 + X)U$. In electric circuits y will represent the current and x the time, while the coefficients A will be the constants of the system and functions of the resistances, capacities, and inductances. The symbolic evolution of the differential equation is then $y = (C + X)/\phi(x')$, where x' is the operator d/dx. The functional operator $1/\phi(x')$ can then be expanded either in ascending powers of x', corresponding to successive differentiations, or in descending powers, corresponding to successive integrations, which together give all possible solutions of the equation. Thus, writing $1/\phi(x') = D \,.\, 1/\phi(x') + S \,.\, 1/\phi(x')$ the general solution is obtained in the form

$$y = C_0\left(D \,.\, \frac{1}{\phi(x')} + S \,.\, \frac{1}{\phi(x')}\right)U + \left(D \,.\, \frac{1}{\phi(x')} + S \,.\, \frac{1}{\phi(x')}\right)XU.$$

Since U is a definite function of x, the first term on the right-hand side is easily calculated, giving Heaviside's theorem, while the second term includes J. R. Carson's generalisation [Abs. 1222 (1917)] as a particular case, as the author exemplifies by so deriving equation (18) of Carson's paper.

Pomey, the translator of Press's paper, supplements it by a free rendering in French of Heaviside's enunciation of his theorem and a proof of its validity in a form adapted for French students. G. W. DE T.

201. *The Dynamical Theory of Electric Engines.* **L. B. Atkinson.** (Inst. El. Eng., J. 59. pp. 1–26, Dec., 1918. Tenth Kelvin Lecture.)—The author first discusses the theory of the action of electric engines converting electric energy into mechanical work, *i.e.* electric motors. Formulæ are found for the efficiency of the ideal engine in every case and the superior limit to this efficiency is pointed out. Cycle diagrams are constructed which show the analogy with the theory of the perfect heat-engine. All the possible primary types of electric engine are enumerated. Electric generators, that is, the engines which convert mechanical work into electrical energy, are next discussed. The theory of the electrostatic generator is explained and the possible future developments are indicated. Finally, combined generator and motor cycles are considered by the principle of the conservation of

energy, first clearly enunciated by Kelvin. The author lays stress on the importance of these considerations to the designer.

The mathematical formulæ are worked out more fully in the Appendices. A. R.

202. *Electrostatic Distributions derived from Electron Theory.* **L. Silberstein.** (Phil. Mag. 36. pp. 413–420, Nov., 1918.)—Electronically the electrostatic distribution on a conducting system is, mathematically and physically, a volume problem. Let $\kappa = \alpha T/3$, where α is the "universal" constant, equal to 3/2 of the gas constant divided by Avogadro's number. Then for T uniform throughout the system, the number of free electrons whose velocities and positions fall within the elements $d\omega$ and $d\tau$ of the velocity space and the ordinary space occupied by the conductor will be, on the ordinary assumption of electron conduction theory, $e \exp.-1/2\kappa.(mc^2/2+\psi)\, d\omega \,.\, d\tau$, where m is the mass and c the resultant velocity of an electron, and ψ, here an unknown function of x, y, z, the potential energy of the electron in the resultant field of force, giving as the number of free electrons per unit volume $C \,.\, e \exp. - \psi/2\kappa = C \,.\, e \exp. \varepsilon/2\kappa(\phi_e + \phi_i)$, where ε is the absolute charge of an electron, ϕ_e the given potential of the external field, and ϕ_i the potential of the unknown distribution of resultant charge within the conductors. Let n be the number of free electrons per unit volume of each conductor when no unelectrified and no external field = number per unit volume of + electrified atoms (assumed fixed) each having charge ε. The resultant density ρ of electric charge at x, y, z, will then be $\rho = n\varepsilon - C \,.\, e \exp. \varepsilon/2\kappa(\phi_e + \phi_i)$. But for no external field and no charge ρ and $\phi_e + \phi_i$ vanish, so that $C = n\varepsilon$. Also if ρ' be the density in an element $d\tau'$ at distance r from x, y, z, then taking the charges in rational units, $\phi_i = 1/4\pi \,.\, \int \rho'/r' \,.\, d\tau$, integrated throughout the conductors, so that the equation for ρ becomes—

$$\log (1 - \rho/n\varepsilon) = \frac{\varepsilon}{2\kappa}\phi_e + \frac{\varepsilon}{8\pi\kappa}\int \frac{\rho' d\tau'}{r'},$$

an integral equation of the second kind with ϕ_e as the known, and ρ as the unknown, function. Although non-linear the superponibility of its solutions is experimentally justified, warranting the assumption that $\rho/n\varepsilon$ is a small fraction, reducing the equation to the form $2\kappa\rho/n\varepsilon^2 = -\phi_e - 1/4\pi \,.\, \int \rho'/r' \,.\, d\tau'$. The ratio of ϕ/ρ having the dimensions of a squared length, we may write $L^2 = 2\kappa/n\varepsilon^2 = 2\alpha T/3n\varepsilon^2$. L is identical with J. J. Thomson's $1/\mu$, taken as thickness of electrical layer ["Corpuscular Theory of Matter," p. 82]. Where the integral equation is not amenable to solution by the methods of the theory of integral equations, we may write $\phi_e + \phi_i = \phi$, and eliminating ϕ by combining the resulting equation $L^2\rho + \phi = 0$ with the fundamental equation $\nabla^2\phi + \rho = 0$, derive the differential equation $\nabla^2\rho = \rho/L^2$. A sufficiently general integral of this being found, its more particular form or coefficients may be obtained by substituting this solution in the integral equation, and using the given total charges $\int \rho d\tau_i = q_i$. As examples of the latter method, the author applies it to the two simple cases of a solid sphere with given total charge and no external field, and a hollow charged sphere with no charges outside the metal (nor in the cavity). G. W. DE T.

203. *Electromagnetic Storm.* **A. Nodon.** (Comptes Rendus, 167. pp. 688–689, Nov. 4, 1918.)—The manifestations occurred from 11h. on the 21st Aug. until the same hour on the 23rd. Observations were made at Bordeaux with magnetometer and electrometer. By aid of the former it was noticed that during the early part of the storm rhythmic and regular

double oscillations of the horizontal component occurred at the rate of 20 per minute: during the night 21st/22nd the number reached 24, and in the morning of the 22nd increased to 32. At the end of the storm the rate decreased to 20.

The electrometer showed variations in the negative charge of the lower layers of the atmosphere and of the surface of the soil, rhythmic and regular, similar to those evidenced by the magnetometer, a direct relation being then demonstrated between the two orders of phenomena, having probably a common origin. The disturbances apparently were caused by sun-spots which occurred simultaneously.

The weather in regard to humidity and temperature suffered changes in the period under notice. The barometer was only feebly affected. The author thinks that the electromagnetic storm was probably the cause, indirectly, of atmospheric and seismic perturbations at other points on the globe. E. O. W.

DISCHARGE AND OSCILLATIONS.

204. *Low-voltage Arcs in Metallic Vapours.* **J. C. McLennan.** (Phys. Soc., Proc. 31. pp. 30–48, Dec., 1918.)—Describes experiments by Harmer and Kemp on lines similar to those of Millikan and Hebb [Abs. 778 and 779 (1917)]. The experiments show that increasing the temperature of the incandescent kathode lowers the voltage necessary to produce arcs in the vapours of Hg, Zn, and Cd. With limed Pt kathodes arcing voltages were not obtained as low as with incandescent tungsten filaments. With highly heated incandescent kathodes it was found that with vapour of low density the arcing potentials were generally high. When the density of the vapour was gradually increased the arcing potential fell and reached a minimum value at a certain density of the vapour. When the density of the vapour was still further increased the values of the arcing potentials rose again. The voltages necessary to maintain the arcs were found to be less than those which had to be applied to strike the arc. With Hg it was found possible to strike arcs with arcing potentials as low as 4·75 volts, and to maintain them with an applied p.d. of 2·84 volts. With Cd vapour arcs were struck with impact voltages of 5 volts, and maintained with p.d.'s of 2 volts. To obtain these low-arcing voltages it was necessary to use intensely hot kathodes and a copious supply of highly heated metallic vapour. In many experiments when voltages near the minimum ones were applied a certain interval of time elapsed between the application of the p.d. and the appearance of the arc. With moderately heated incandescent kathodes and a moderate supply of vapour the arcing voltages for Hg, Zn, and Cd are given by the quantum relation $Ve = h\nu$, where ν is the frequency of the shortest wave-length of the $\nu = (1{\cdot}5, S) - (m, P)$ series. With Cd vapour it was found possible to set up two types of arc in the vapour, the one being faint and the other brilliant. The line spectrum of the two types appeared to be the same in character, but different in intensity. Additions to the applied field of not more than a volt generally sufficed to turn the faint into the brilliant type, with which a continuous white-light spectrum was superimposed on the line spectrum. Irregularities in the experimental results were in a measure removed when the metal being vaporised was electrically connected to the positive terminal of the discharge tube. A. W.

205. *Low-voltage Arcs in the Vapours of Hg, Na, and K.* **T. C. Hebb.** (Phys. Rev. 12. pp. 482–490, Dec., 1918.)—Describes experiments on the ionisation potentials of Hg, Na, and K, with special reference to the produc-

tion of low-voltage arcs in these vapours. It is shown that potassium vapour can be ionised at 1·6 volts, which is its resonance voltage, and that sodium vapour can be ionised at 2·5 volts, which is very close to the resonance voltage. This result agrees with that found by Wood and Okano. It was found that the D-lines of sodium can be excited at less than 1·0 volt ; also in agreement with Wood and Okano. Sodium and potassium arcs in mercury vapour can operate below their resonance potentials, and as low as 1·4 volts for Na and 0·5 volt for K. It was also found that the mercury spectrum can be produced at as low as 0·5 volt in an atmosphere of mercury and potassium.

The results are discussed at some length. [See Abs. 778 (1917).] A. W.

206. *Diffraction of Electric Waves by the Earth.* **G. N. Watson.** (Roy. Soc., Proc. 95. pp. 83–99, Oct. 7, 1918.)—The earth is supposed to be a homogeneous imperfectly conducting sphere of radius a surrounded by infinite homogeneous dielectric. The transmitter is a Hertzian oscillator at distance b $(>a)$ from the centre of the sphere with its axis, taken as the axis of harmonics, radial to the sphere. The oscillator emits simple harmonic waves of period $2\pi/\omega$, and the electric and magnetic forces are the real parts of the vectors $\mathbf{E}e^{i\omega t}$, $\mathbf{H}e^{i\omega t}$, $\mathbf{E}$ and $\mathbf{H}$ being related by the equation $\beta\mathbf{E} = \text{curl } \mathrm{H}$, $\gamma\mathrm{H} = -\text{curl } \mathbf{E}$, where β and γ are constants of the transmitting medium. The problem is then the purely mathematical one of the approximate summation of a complicated oscillatory series. Poincaré [Abs. 1322 (1910)] and Nicholson [Abs. 430, etc. (1910)] replaced the series by an integral which was then approximately evaluated by the calculus of residues. These approximations, however, became invalid near the antipodes of the transmitter, and the author considers their analysis defective in some points of detail. Macdonald [Abs. 1313 (1914)] approximates to the terms of the series and then replaces the modified series by an integral under conditions not strictly justifiable mathematically, and, moreover, uses an approximation not valid to the extent assumed, which is the principal source of the discrepancy between his results and those of Poincaré and Nicholson. March [Abs. 569 (1912)] and Rybczynski [Abs. 1489 (1913)], in dealing with an oscillation on the positive half of the axis of harmonics, express a Hertzian function by an integral of $\mathrm{P}_s(\cos\theta)$, whereas in dealing with harmonics of non-integral degree, the appropriate function is $\mathrm{P}_s(-\cos\theta)$. This, as Love has pointed out in a directly arithmetical treatment of the problem [Abs. 1109 (1915)], vitiates the whole of their analysis, the expression assumed for the magnetic force having a line of singularities along the negative half of the axis of harmonics.

The present author starts with a Hertzian function identical with that of Love in the case of an oscillator surrounded by infinite homogeneous dielectric, and identical also, except for a formal factor, with that of March. Avoiding the error pointed out by Love, the series for the magnetic force is derived from the Hertzian function, and is then transformed by the calculus of residues into a rapidly convergent series well adapted to numerical computation. Poincaré's analysis leads only to an approximation to the dominant terms of the latter series, but the more powerful contour integrals of the present paper give the complete series. The use of the Hertzian function and Bessel function of the types employed by March, makes the analysis remarkably concise. The expression obtained for the magnetic force at the antipodes of the transmitter shows that the effect of the waves which pass through the earth is trivial compared with that of those which traverse the atmosphere. G. W. DE T.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

207. *The Measurement of High Voltages.* **P. Joye.** (Archives des Sciences, 46. pp. 243–251, Oct.–Nov., 1918.)—This paper describes a method of measuring the secondary voltage of a step-up transformer by means of a tertiary coil situated between the two halves of the secondary. The terminals of the tertiary coil are connected to a voltmeter of small inductance and large resistance.

The problem is treated (1) mathematically, and (2) practically. An expression is found for the voltage ratio of the secondary to the tertiary circuit. Experiments with an iron-cored coil at 50 ∼, show a close agreement between theory and practice. The secondary voltages used, varied between 14,000 and 34,000. N. W. M.

208. *Absolute Electrodynamometer.* **A. Guillet.** (J. de Physique, 7. pp. 114–127, May-June, 1917.)—The electrodynamometer consists of two pairs of fixed coils in horizontal planes and two flat movable coils suspended at the ends of the beam of a sensitive balance. For the accurate determination of small forces, or small changes of force, one end of the balance beam is extended and from a knife-edge at its extremity an accurately divided scale is suspended. The balance is also fitted with a mirror for the swings and displacements to be read by means of a reflected spot of light. The mutual inductance of the coils is not calculated, but is obtained by comparison with another carefully calculated standard. If M is the mutual inductance of the electrodynamometer system, the constant of the instrument is dM/dx, where x is the vertical displacement of the moving coils from the electrical centre of the system. The difference between the mutuals when the moving coils are displaced vertically is also readily measured and so $dM\ dx$ is determined. F. E. S.

ALTERNATING CURRENTS AND MAGNETISM.

209. *Development of Magnetic Susceptibility in Manganese Steel by Prolonged Heat Treatment.* **C. F. Brush.** (Am. Phil. Soc., Proc. 57. pp. 344–353, 1918.)—The author has previously called attention to the spontaneous generation of heat in water-quenched carbon, high-speed and chrome-nickel steels [Abs. 564 (1917) and 586 (1918)] and has continued his experiments on a Mn steel containing 1·1 % C and 12·29 % Mn. No spontaneous generation or absorption of heat was brought about by quenching this steel at any temperature, whether rising or falling, while in its normal useful non-magnetic condition. Further experiments were made therefore with a view to studying the development of the magnetic condition by prolonged annealing at moderate temperatures in a specially designed furnace in which the magnetic susceptibility could be measured at any desired temperature. The bars were first brought to the condition of max. softness (scleroscope No. 26) by quenching from 1000° C., when they were absolutely non-magnetic. After 120 hours heating at 505°–525° C. the susceptibility had risen to 35 (Swedish iron = 100). During the next 50 hours the susceptibility fell slightly, and after this time the bars were quenched and found to exhibit moderate spontaneous generation of heat and to have a hardness of 41. Further heating raised the susceptibility to 62, but raising the temperature to above 600 C. produced a remarkable drop in the susceptibility. After 344 hours at just below 600° C. the susceptibility rose to a value comparable with that of ordinary steel, but the generation of heat after quenching was very little indeed. The remarkable feature was that in spite of the great increase of

susceptibility the hardness had fallen to 37—a fact which probably accounts for the lack of heat generation. F. C. A. H. L.

210. *Variation of Physical Properties of Iron Alloys with Composition and Treatment.* **E. Gumlich.** (Phys. Zeits. 19. pp. 434–436, Oct. 1, 1918. Paper read before the Deut. Busen-Gesell., April, 1918.)—The material tested consisted of dynamo iron from various sources, in the compact form and also in cylindrical bars and thin sheets, also alloys containing C, Si, Al, and Mn. The properties tested were those of density, resistivity, position of the first and second critical temperatures, and especially the magnetic properties by means of hysteresis cycles and losses, coercive force, remanence, initial and max. permeability, and saturation value. In general, the effect of thermal treatment on density and resistivity is small, and only of importance in the C and Mn alloys; on the other hand it strongly affects the magnetic properties by removing the mechanical and magnetic hardness produced by the rolling of the metal. Further, heating causes the C and O contained in the metal to combine in the form CO which is then driven off. A molecular deterioration is at the same time introduced. The best heating temperature found was 800°. Electrolytic iron gave magnetisation curves which could be altered at will by thermal treatment; slow cooling after heating gave a steep magnetisation curve with relatively high max. permeability, whereas rapid cooling gave a more oblique curve with lower max. permeability, but with smaller hysteresis loss. After repeated heating, this sensitiveness disappeared, and the final curve lay far down, the remanence being 850 and coercive force 0·15 gauss. Such material would be useful for cores in electrical measuring instruments which have had to be made hitherto without iron on account of the remanence of the latter. In the case of the alloys, extrapolation gave for zero content of alloyed metal, *i.e.* for pure iron, density 7·876, resistivity 0·0994 ohm per metre/mm.^{2} at 20°, resistance temperature coefficient 0·57 %. Addition of Si and Al causes a great increase in resistivity and in the Al alloys the temperature coefficient is much diminished. As regards magnetic properties, carbon plays the most important part. It enters in three ways: as graphite in the tempering process when it is magnetically almost neutral; as iron carbide Fe_3C (cementite and pearlite); and as dissolved carbon (martensite). The last two cause a lowering of μ and an increase of hysteresis loss, and coercive force amounting to 7 gauss in pearlite and 70 gauss in martensite per 1 % carbon. In the latter form which appears during rapid cooling, carbon impurities of a few thousandths per cent. cause great deterioration in magnetically soft metal and must be kept out at all costs. On the other hand, the properties produced are useful in permanent magnets. With increase in dissolved carbon coercive force increases but remanence diminishes; it is here that additions of Wo, Mo, and Cr have a good effect. Increase of carbon causes a decrease in the temperature coefficient of magnetic moment, and permanent magnets have been made with 1·4 % C, and hardened at 1000°, which had no temperature coefficient. Silicon alloys have been much used for transformer material on account of their high resistivity and consequently smaller eddy-current losses; they have also good magnetic qualities in low fields. But the addition of Si diminishes the magnetic quality of pure iron. The improvement effected by Si is of a secondary nature; with 4 to 5 % Si the carbon impurities do not remain in solution, but are separated out in the form of pearlite which again, by long heating and slow cooling, can be transformed into the innocuous form of graphite. Additions of Al have a similar effect although, probably owing to

technical imperfections, the good results obtained with Si have not been reached. By heating at 1100°, the remanence of the 10 % alloy of Al is reduced to 1500. The magnetic qualities of Mn alloys have not yet found an application in practice. They are similar in some respects to the carbon alloys ; in certain circumstances the coercive force rises to 130 gauss (C alloys, 70 gauss), but the simultaneous drop in remanence excludes their use as permanent magnets. In contrast with the C alloys, quenching makes the metal magnetically softer. With between 8 and 10 % Mn there are sudden changes in the density, resistivity, coercive force, and saturation value which are caused by the appearance of austenitic constituents. These cause total disappearance of susceptibility in alloys of 14 % Mn and over. With increase of Mn content, the Ac2 point sinks from about 760° to 660°, and the Ar2 point sinks much further so that in the 12 % alloy it lies much under ordinary temperature. A specimen can thus be produced either in the magnetic or non-magnetic condition according as it has been previously heated above Ac2 or cooled. These two forms have different densities and resistivities. The transition from the austenitic to the martensitic state takes place suddenly, and is frequently perceptible as an audible crack. The whole process is similar to that which obtains in the irreversible Ni-steels which are now so extensively used in the manufacture of armour plating. G. E. A.

211. *Twist and Magnetisation of a Steel Tube in a Spiral Magnetic Field.* **F. E. Hackett.** (Roy. Dublin Soc., Proc. 15. pp. 415-430, Oct., 1918.)—A spiral magnetic field S whose axis coincides with that of a cylindrical magnetic shell produces in the latter an elongation ε_1 along the lines of force and a contraction ε_2 normally to their direction. This elementary strain causes a twist θ of the cylindrical shell and an elongation along its length. Knott has given the relation $\theta = (\varepsilon_1 + \varepsilon_2) \sin 2\alpha\, l/r$ for this case, where l is the length of the cylinder, r its mean radius and α the pitch angle of the spiral field. If a longitudinal field H and a circular field F be compounded to produce the spiral field, the latter may be kept constant while the ratio H/F is varied. Under these conditions $\theta \propto \sin 2\alpha$. The author has investigated this experimentally in the case of a steel tube 95 cm. long, 0·87 mm. thick, and 5·94 mm. mean radius. The circular field was produced by a current along a wire fixed in the axis of the tube, and the tube was placed centrally in a solenoid producing the longitudinal field. The experimental arrangement admitted of reading a twist of 3·77 microradians. Hysteresis effects were eliminated by setting the circular and longitudinal fields and then superimposing on these a longitudinal field which was slowly decreased to zero with reversals at the rate of 1 per sec. For low spiral fields the linear relation holds, but with higher fields the graph of twist and pitch angle is slightly concave to the axis of pitch. This is probably to be accounted for by the effect of the demagnetising factor and the variation of susceptibility with direction.

The longitudinal intensity of magnetisation under the same type of spiral field is then investigated, the one-pole magnetometer method being employed. If it be assumed that (1) the magnetisation is parallel to the spiral field, (2) the susceptibility is the same in all directions, (3) the demagnetising effect can be neglected, then the longitudinal intensity of magnetisation should be proportional to the sine of the pitch angle. Data obtained anhysteretically are shown graphically and the slight deviations from the linear law are to be accounted for by the theoretical assumptions not being fulfilled.

A second method is then employed for obtaining the spiral fields, the

circular and longitudinal fields being allowed to grow up from zero simultaneously, so that the pitch angle remains constant. In this case the magnetisation is of necessity parallel to the field and deductions from the experimental observations can be made with regard to the magnitude of the demagnetising factor. This factor for a steel tube is approximately the mean of the factors for a solid cylinder of equal radius and a cylinder of equal sectional area. A similar result is arrived at by considering the slope of the anhysteretic curve which has a finite value at the origin. L. L.

212. *The Curie Point in Pure Iron and the Ferro-silicons.* **A. Sanfourche.** (Comptes Rendus, 167. pp. 683–685, Nov. 4, 1918.)—The temperature of the thermal change corresponding to the rapid increase of magnetic susceptibility of iron at 1280° C. discovered by Curie has been redetermined. On heating the temperature was found to be 1365° C., and on cooling 1310 C. This is the point A4 corresponding to the $\gamma \rightleftarrows \delta$ transformation. The addition of Si to the iron results in a lowering of the temperature at which A4 occurs, while at the same time the intensity of the heat change is diminished until, with 2·5% Si, it is too small to be determined. The following table summarises the results :—

Percentage of Silicon.	Ac4 (Heating).	Ar4 (Cooling).
Pure iron	1365° C.	1310° C.
0·5 % Si	1355	1294
1·0 % Si	1342	1281
1·5 % Si	—	1259
2·0 % Si	1297	1225
2·5 % Si	—	1195

F. C. T.

213. *Bohr's Atom and Magnetism.* **J. Kunz.** (Phys. Rev. 12. pp. 59–69, July, 1918.)—The author points out that, while Bohr's theory leads to the relation—the square roots of the highest frequencies of any two chemical atoms vary as the charges of their nuclei—which is required by the results of Moseley's observations on the Röntgen spectra, it can also be derived without assuming the truth of Bohr's theory, provided the quantum relation is introduced in the way employed by F. Sanford [Abs. 783 (1917)]. Both methods equally involve the assumption that the mass of the electron is the same for all elements. Assuming the ratio of the transverse mass of an electron within the atom to the rest mass to be that given by the relativity theory, the relation stated above gives $2{\cdot}1 \times 10^{10}$ cm. as the max. velocity of the electrons in the uranium atom, corresponding to a transverse mass of 1·4 times the rest mass, and in the case of other elements, *e.g.* H and He, the highest velocities are also about 30 %, only below the velocity of light, a result which must be taken into account in framing a satisfactory relativity theory of the Röntgen spectra. The electron velocities in Bohr's theory being so great, it would seem that the magnetic properties of the elements might be accounted for on the assumption of a few electrons revolving in non-radiating orbits. But calculations on Bohr's theory of the magnetic moments and susceptibilities make both H and He paramagnetic. H is, so far, doubtful, but He, like other inert gases, is certainly

diamagnetic. So here Bohr's theory would break down. But the author shows that if conservation of moment of momentum holds good within the atom, and if this momentum is proportional to the magnetic moment, the assumption of ellipticity in the electronic orbits would be sufficient to account for the observed diamagnetism. G. W. DE T.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

214. *Advance in the Design of X-ray Tubes.* (Wireless Age, 5. pp. 982–985, Sept., 1918.)—The Coolidge X-ray tube operates at extremely high vacua with a pure electron discharge, as contrasted with the Röntgen tubes formerly constructed depending in their action upon the ionisation of a residual gas. In one of the modifications of this tube the kathode rays are focused by means of a static focusing device, such as a ring tube, or other conductive member surrounding the kathode and establishing a static field radially about the kathode. The focusing member appears to become statically charged by the electron emission of the kathode, and thus modifies the static field in the tube, which is controlling the motion of the kathode rays. Langmuir has designed a tube wherein the length of the focus of the kathode rays is varied at the will of the operator, thus controlling the area of the focal spot or surface by adjusting the distribution of potential in the static field, directing the kathode-rays inwardly to a common point or outwardly from a virtual focus. By means of a source of potential between the kathode and the focusing device, the intensity and polarity of the static field may be varied in a manner here fully described with the aid of diagrams. When the focusing member is connected to the kathode without interposing any source of potential, one of the surfaces which may be plotted in space to include points of the same potential, will include the tip of the filament and the outer edge of the focusing tube. As such equipotential surfaces approach the anode they become less concave. The electrons emitted by the filament when travelling from the kathode to the anode, tend to move perpendicularly to these equipotential surfaces, and are thus directed toward a spot of restricted area upon the anode, called the focal spot. When a source of potential is introduced into circuit between the kathode and focusing member, the positive terminal being connected to the focusing member, the shape of the equipotential surfaces will be changed, as the tip of the filament and the rim of the focusing member no longer are at the same potential. By making the positive potential high enough the focusing of the rays may be entirely prevented, that is, the rays will diverge instead of converge. By making the potential negative with respect to the focusing tube the focal area may be made smaller, or, in other words, sharpness of the focusing may be improved. The charge on the focusing member also has an effect on the resistance of the tube and hence on the hardness of the X-rays. A positive charge decreases the hardness, and a negative charge increases the hardness in proportion to the potential of the charge. A. E. G.

215. *X-Ray Fluorimeter.* **Guilleminot, H. Choron** and **R. Biquard.** (Comptes Rendus, 167. pp. 594–595, Oct. 21, 1918.)—Describes a form of fluorimeter in which the brightness of a barium platinocyanide screen is compared with a surface of radium luminous compound containing 0·05 mgm. of radium bromide per gm. The latter surface is protected from the action of the X-rays. This apparatus is stated to give more accurate results than the usual forms of quantitometer. J. W. T. W.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

216. *Gases and Vapours from Glass.* **R. G. Sherwood.** (Phys. Rev. 12. pp. 448–458, Dec., 1918.)—By means of a dynamic method the author has measured the quantity of gas and vapour driven off from glass under the influence of heat. It is found that there is a slow but persistent leakage of occluded gases from glass exposed to a vacuum even at room temperature, and this leakage is more rapid for the inert gases than for vapours. The adsorbed gaseous layer has been found to be of a thickness comparable to a layer one molecule deep. There are two distinct kinds of gaseous evolution products from glass which is being heated ; the one associated with adsorption, readily removable at temperatures as low as 200° C., and the other in all probability resulting from the formation of new chemical equilibria.

A. F.

217. *Liquid Crystals.* **J. E. Fletcher.** (Engineering, 106. p. 382, Oct. 4, 1918.)—It is suggested that the structure of a white cast iron is consistent with the idea that liquid crystals are first formed in the melt. F.C.T.

218. *Definition of Valency.* **F. H. Loring.** (Chem. News, 117. pp. 319–322, Oct. 11, 1918.)—The author discusses in a general way the question of valency, and points out that valency is, on the whole, a somewhat elastic conception. Quotations are given from various sources in order to show that not only do differences of opinion exist with regard to matters relating to valency, but that speculative studies in respect of cohesion probably point the way to a wider or, rather, a more extended view of the whole subject, while experimental evidence, as instanced by X-ray analysis, is of great value. A. F.

219. *The Search for two New Metals, Neo-molybdenum and Neo-tungsten.* **M. Gerber.** (Mon. Scient. [V] 7. pp. 73–83, April ; 121–127, June ; 169–177, Aug., and pp. 219–226, Oct., 1917.)—According to the periodic table there should be, parallel to the group : chromium (at. wt. 52), molybdenum (96), tungsten (184), a group of three elements, namely, manganese (55)—99—187 ; the two last elements are missing. Searching for them the author first investigated large bulks of manganese salts from various sources and of ferromanganese, and then turned to ores and salts of molybdenum and of tungsten. That both these metals are not really elementary, has repeatedly been suggested. The author finds evidence of a new element neomolybdenum of atomic weight 99, and also of a neotungsten, at. wt. 187. As regards the latter a green (not yellow) tungsten acid had been described by A. Laurent, 1844, and F. A. Bernoulli, 1860, and others had observed peculiarities suggesting the presence of an unknown constituent. Spectroscopically these new metals are indistinguishable from molybdenum and tungsten respectively, and they might hence be isotopes, it is suggested ; however, radio-active tests are not mentioned. H. B.

220. *Influence of Forging on the Properties of Steel.* **G. Charpy.** (Rev. de Mét. 15. pp. 427–448, Sept.-Oct., 1918.)—A criticism of the custom of inserting a "coefficient of forging" (equal to the ratio of the initial dimen-

sions of the ingot to the final ones of the finished article) in specifications. Since it is seldom possible to increase the length of an ingot to more than double at one operation in the press or under the hammer, such a coefficient of 3 or 4 necessitates at least two heatings, resulting in waste of fuel and labour, while great expense is caused by the ponderous installation required to deal with the large initial masses. The erratic nature of the action of hammering upon a bar is indicated by the following figures. A bloom 550 mm. square was hammered down to 250 mm. square in six passes, the total length increasing 4·8 times. The local increase, however, varied from 2·37 to 7·30 times. Rolling, on the other hand, produces a deformation which is sensibly uniform. The influence of the amount of work put upon a gun steel is illustrated by the following table.

Coefficient of Working.	Longitudinal.				Transverse.			
	Max. Stress. kg./mm.²	Elongation. %	Reduction in Area. %	Impact. kg.-m.	Max. Stress. kg./mm.²	Elongation. %	Reduction in Area. %	Impact. kg.-m.
1·7	91·2	20	52·5	0·8	90·9	18	43	5·5
3·2	91·6	20	58	8·1	90·5	16	37	4·0
6·1	90·5	20	62	10·0	90·6	12	23	3·5

The deleterious effect of the continued forging upon the properties of the steel in a transverse direction are well shown, this effect being specially noteworthy in steels high in S and P. The explanation of these facts is found in the gradual alignment of the primary dendrites as the section of the ingot is successively reduced, the structure when the parallelism becomes complete being one readily susceptible to fracture under stresses parallel to the dendrites. The influence of the direction of the impact stress on a steel which has been subjected to a considerable amount of forging is shown by the following figures :—

Angle made by notch in test with the direction of rolling (transverse) ...	0	20	45	90 longitudinal
Impact No., kg.-m.	1·3	1·5	3·4	13·5.

F. C. T.

221. *The System Iron-Copper.* **R. Ruer** and **F. Goerens.** (Ferrum, 14. pp. 49–61, Jan., 1917.)—A continuation of the work of Ruer and Fick [Abs. 366 (1915)]. As before, samples of 25 gm. of each of the two metals were quickly heated up in a porcelain tube (Tammann furnace) and then stirred with the quartz sheath of the thermo-couple, a current of nitrogen being maintained through the tube. The materials were electrolytic copper (99·95 % Cu) and a very pure iron with 0·0002 % C. ; in the further thermal investigation electrolytic iron was used. There was always a separation of the melt into two layers, the upper rich in iron, the lower rich in copper ; the separation was sharply defined, especially at high temperatures. The compositions of those two layers changed with the temperature, there being 82·31 and 90·6 % Cu in the heavier layer at 1440 and 1569° C. respectively. The lower layer showed more tendency to undercooling than the upper. The extreme percentages mentioned seem to be incompatible with the melt-

ing curve, according to which the temperature-fall corresponding to these concentrations should be 200 deg. It is definitely shown that the middle portion of the freezing curve is not horizontal; on solidifying the system, Fe–Cu behaves therefore like a system of three or more substances. Yet impurities were not taken up by the metals during the treatment, and the analyses for the nitrogen percentages in the metals always yielded values below 0·03 %. It is hence suggested that a molecular complex, slow in formation and decomposition, plays the part of a third substance; but the authors acknowledge that they have no further support for this apparent contradiction of the phase rule. The transformation temperature of the γ–β change in iron was lowered by the addition of copper from 906° to 823°; the $\beta - \alpha$ change was lowered by 1 % Cu from 769° to 759°. From electric conductivity measurements it was concluded that iron can only contain 1 % Cu in solid solution at ordinary temperature. This result is contradicted, however, by the study of the structure; copper can dissolve 1 or 2 % Fe. The magnetic permeability changes occurred in copper of 95 % at the same temperature as in copper of 50 % and less. H. B.

222. *Researches on Alloys Rich in Zinc.* **L. Guillet** and **V. Bernard.** (Rev. de Mét. 15. pp. 407–425, Sept.–Oct., 1918.)—An account of experiments made with the object of discovering a high-zinc alloy of approximately the same properties as 70/30 brass, namely, max. stress 28–32 kg.-mm.^{2}, elongation 25–30%, impact number 3–5 kg.-m. The nearest results were obtained with an alloy of commercial zinc (Pb 1–1·2 %) and 1·5–2 % Cu which gave, when drawn into wire, a max. stress of 30–31 kg./mm.^{2} and an elongation of 27–28 % and with an alloy containing 8 % Cu and 4 % Al, which in the form of wire had a tensile strength of 36 kg./mm.^{2} and an elongation of 24 %. In all cases the resistance to impact was much less than that of a 70/30 brass. The tests given by the rolled alloys were far less satisfactory than those of the drawn samples. The micro- and macro-structures of the alloys are discussed and twenty micrographs given. Hardness determinations were made and portions of the thermal-equilibrium diagrams of the systems constructed. The best temperature for rolling and wire-drawing was discovered to be about 125°–139° C. F. C. T.

223. *Electrical Conductivity of Acids and Bases in Aqueous Solutions.* **J. C. Ghosh.** (Chem. Soc. J., Trans. 113. pp. 790–799, Oct., 1918.)—This is a continuation of the author's previous work [see Abs. 881 (1918)]. The abnormally high mobility of the hydrogen and hydroxyl ions in aqueous solutions has been explained on the assumption that electricity is partly carried by the ordinary process of convection and partly propagated through water molecules undergoing alternate dissociation and recombination. The apparently high activity-coefficients of strong acids and bases in aqueous solutions have also been traced to this cause. A modified Ostwald equation $(\alpha v)^2/(1 - \alpha)V = K$, based on the consideration that only free ions have the capacity of regenerating undissociated molecules, has been developed for weaker electrolytes, where the degree of dissociation is less than unity. It has been shown that this equation becomes identical with Ostwald's dilution law in the case of very weak electrolytes, where α is always very nearly equal to one, and also gives very concordant values for the equilibrium constant in the case of "transition electrolytes" where Ostwald's equation is not applicable. A. F.